Olivia Clark

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Clock Radio Lab Report

I: Introduction Paragraph

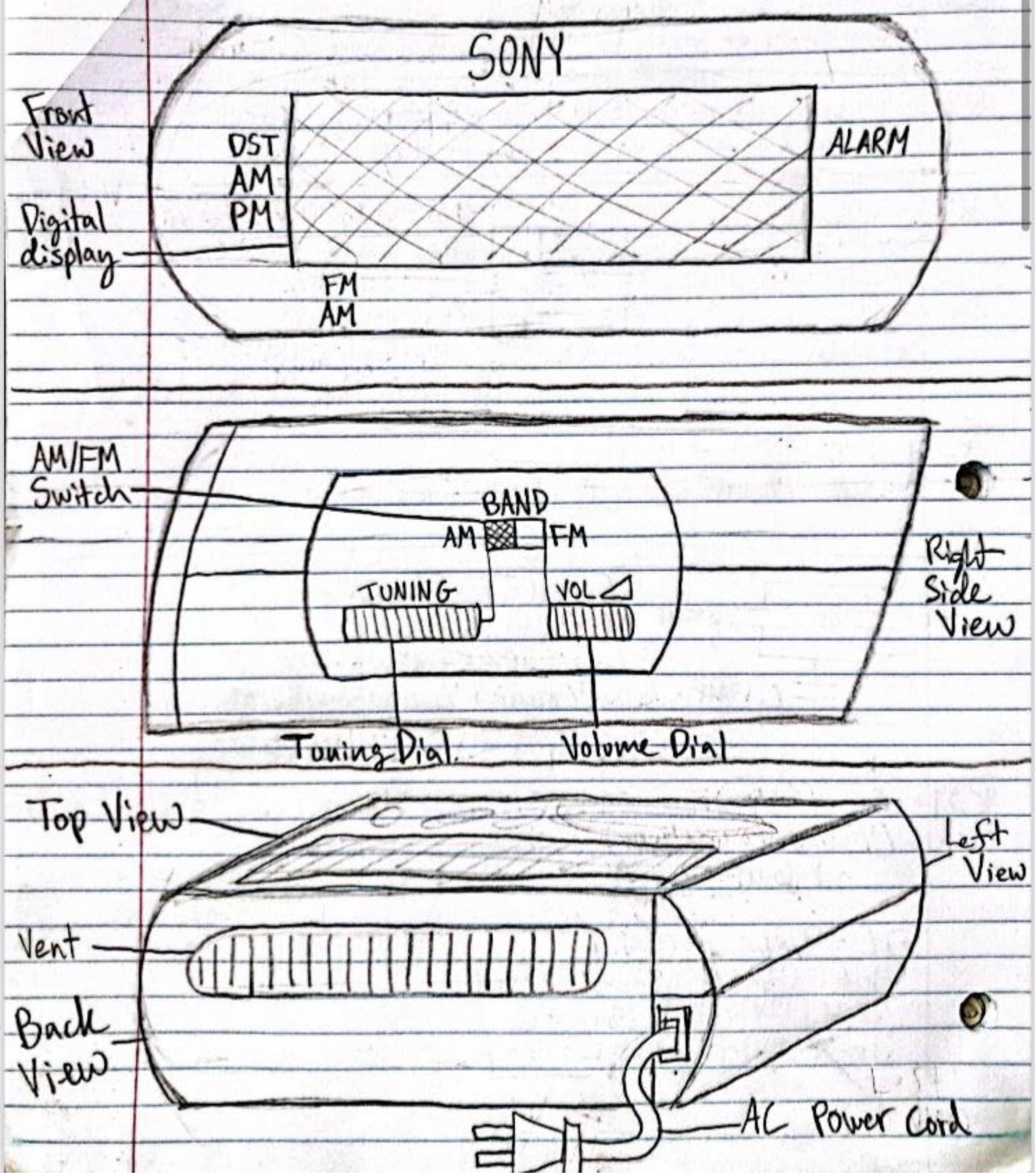
Through this lab, I hope to apply my understanding of electricity and circuits to identify and analyze the use of electric circuits in the application of a clock radio. I hope to develop a greater understanding of the applications of electricity in complex circuits and how they can perform observable, practical functions. I hope to gain an insightful introduction on the relationship between electricity and magnetism and our ability to harness the electromagnetic spectrum so as to use and intercept radio to communicate. I expect to be surprised and intimidated by this project, but I hope to learn enough in the process to be able to answer my own questions by the end of it. I expect that this project will introduce me to new ideas and provoke new questions that will further my curiosity and therefore research and knowledge on the subject.

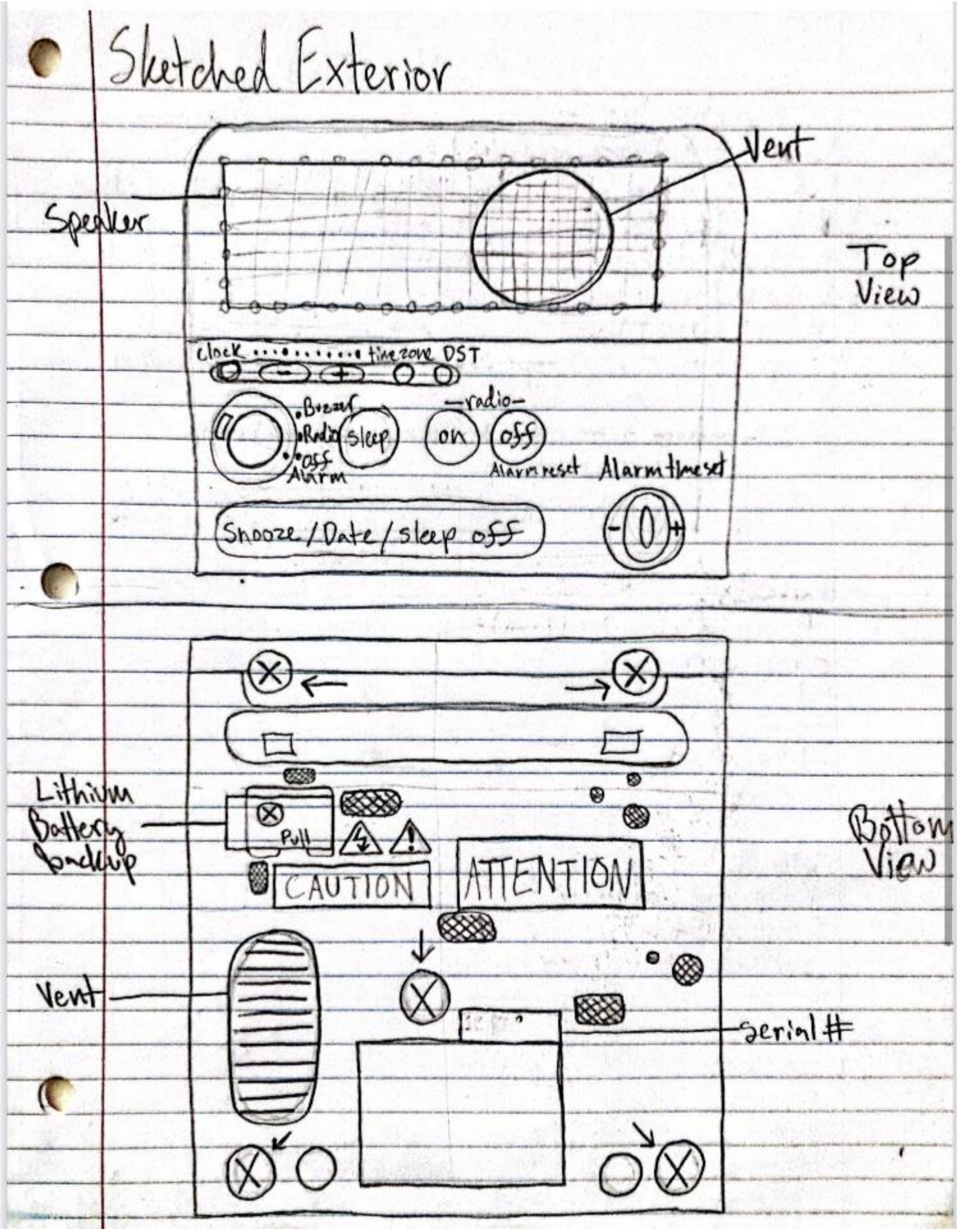
II: Materials List

- Philips Screwdriver
- Flathead Screwdriver
- Wire Cutters/Scissors

III: Sketched Exterior

Sketched Exterior




Sketched Exterior
Vent
Speaker
Top View
clock
timezone DST
Buzzer
Radio
Off
Alarm
sleep
radio
on
off
Alarm reset
Alarm time set
Snooze / Date / sleep off
Lithium Battery backup
Pull
CAUTION
ATTENTION
Bottom View
Vent
Serial #

IV: UL Listing

AC Voltage (V)	Wattage (W)	Frequency (Hz)	DC Power Backup (V)
120	5	60	3

V: Exterior Deconstruction

1. Remove 5 screws from the lower cabinet with the Philips screwdriver
2. Remove front display panel by undoing (not removing) top 5, side 2, and bottom 1 claws.
3. Lift and remove the upper cabinet
4. Remove the lithium battery by removing the indicated screw with the Philips screwdriver

VI: Interior Deconstruction

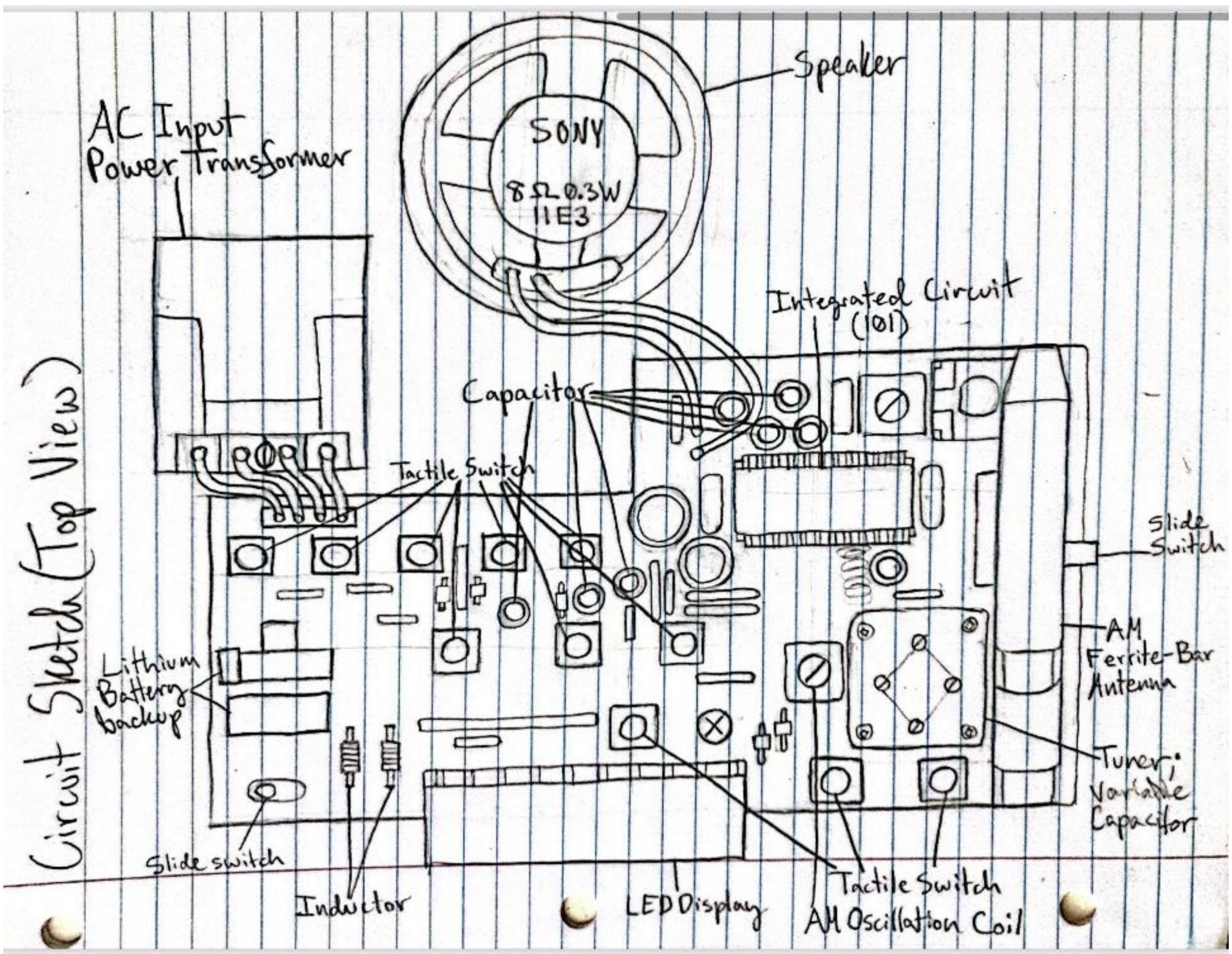
1. Undo claws on circuit board
2. Unscrew 1 screw from the circuit board
3. Remove circuit board and AC power transformer from the lower cabinet
4. Remove tuning dials from the bottom of the board by pulling them off
5. Remove adhesive from speaker to remove from the upper cabinet
6. Remove adhesive from antenna to remove from the circuit
7. To remove other circuit components, pry and cut from beneath the soldered part

VII: Removed Pieces

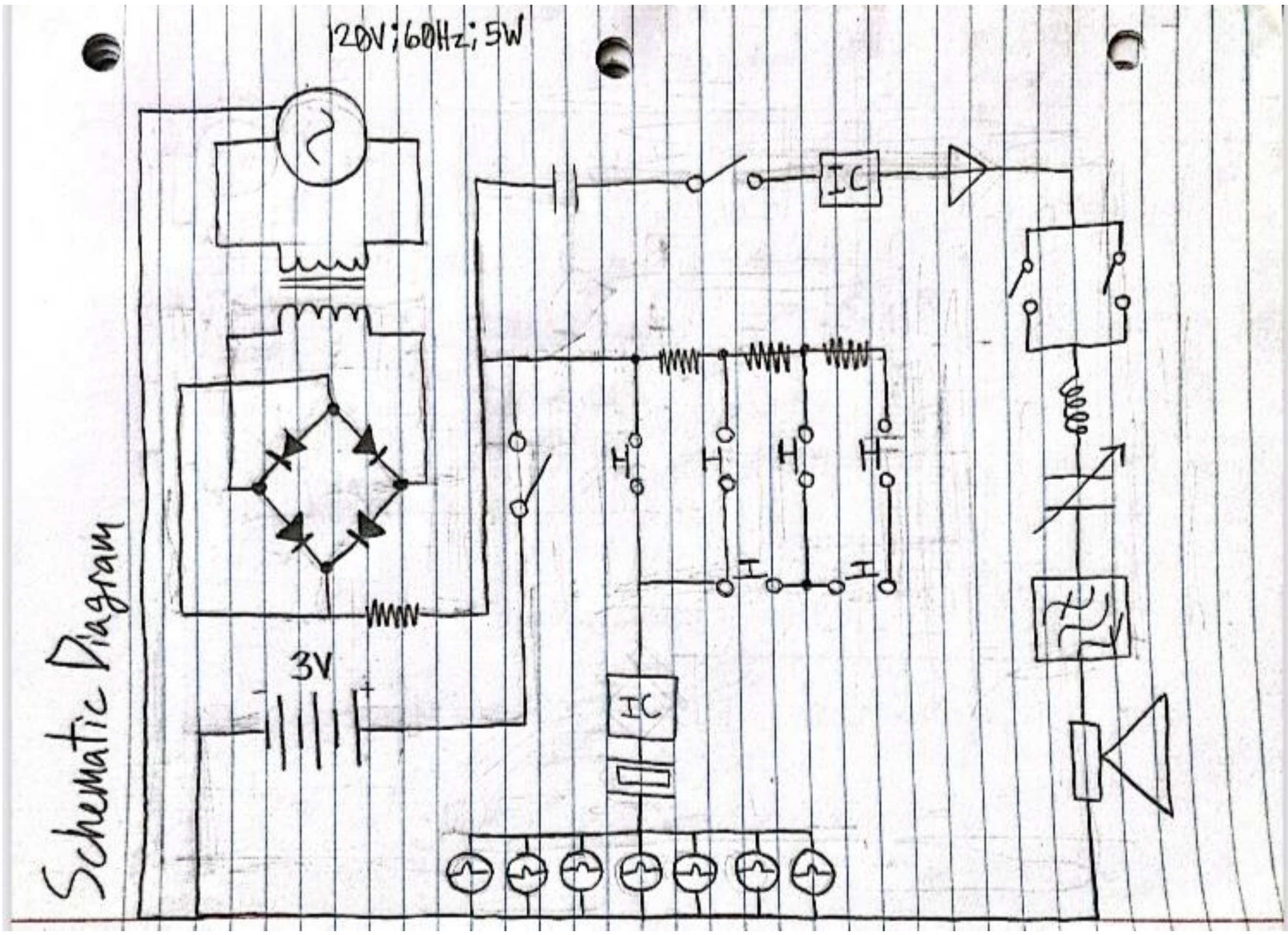
Screws	Dials	Resistors	Capacitors	Transformer	Antenna	Speaker	Battery
7	2	0	4	1	1	1	1

Diodes	Variable Capacitor						
0	1						

VIII: Sketched Interior

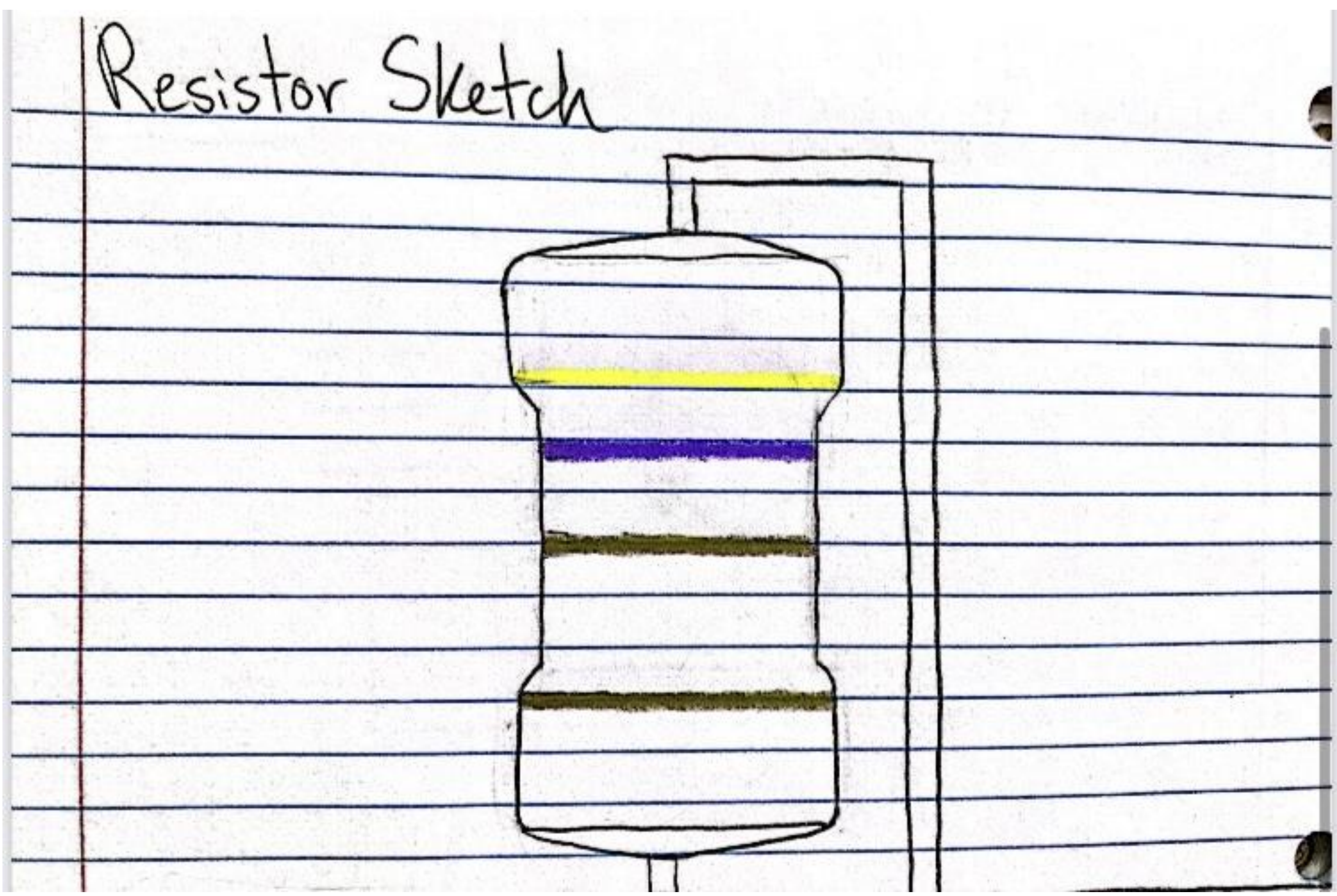


IX: Schematic Diagram



X: Resistor Analysis

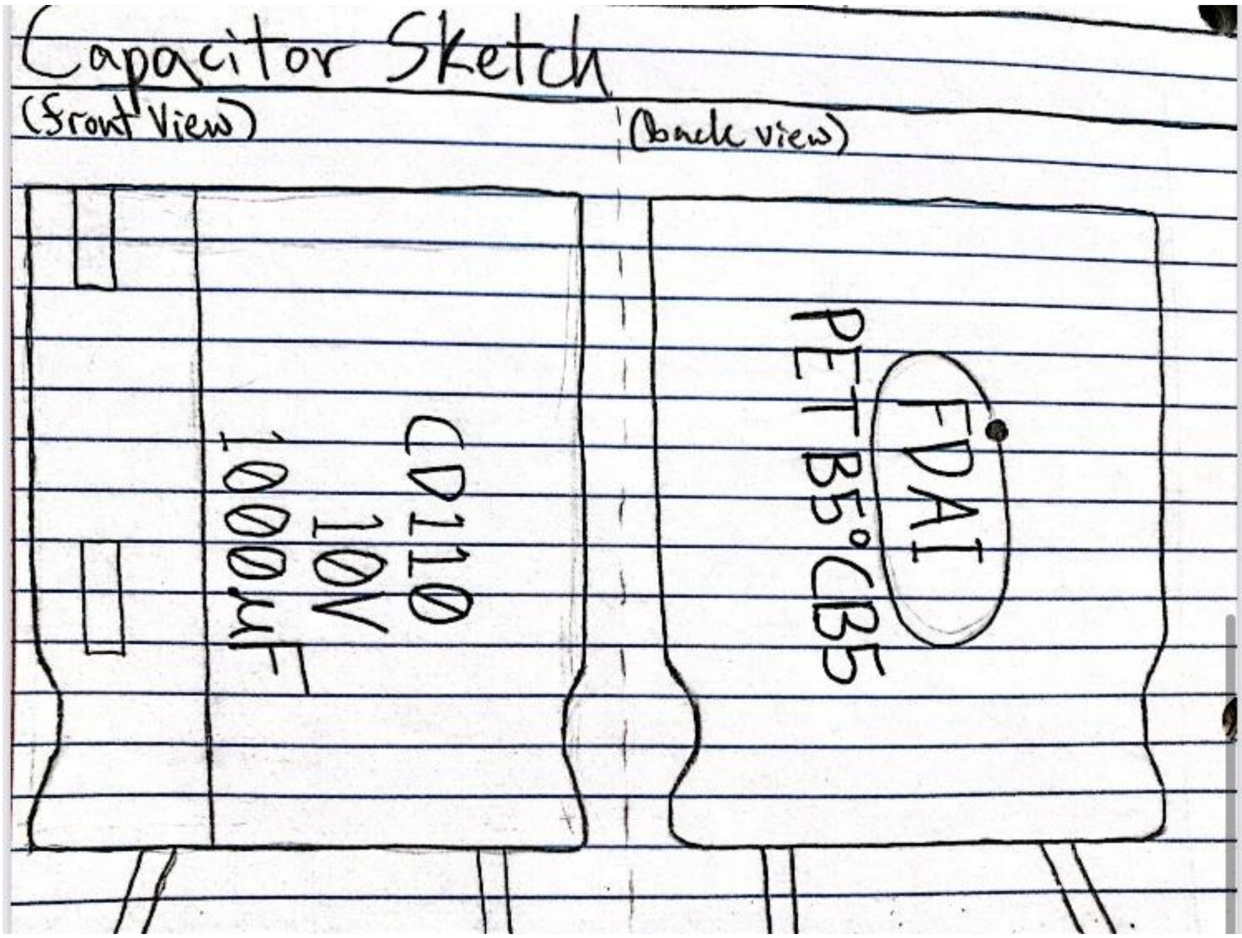
Considering that my clock radio is relatively new, the resistors were too small for me to remove from the circuit. However, I deconstructed an older digital weather alert radio and removed a resistor from the circuit within it. I was able to decipher the markings on this resistor using an online 4-Band-Code calculator. The resistor has 4 bands colored yellow, violet, gold, and gold. Inputting this into the 4-Band-Code calculator tells me that the resistor has 4.7 Ω of resistance.



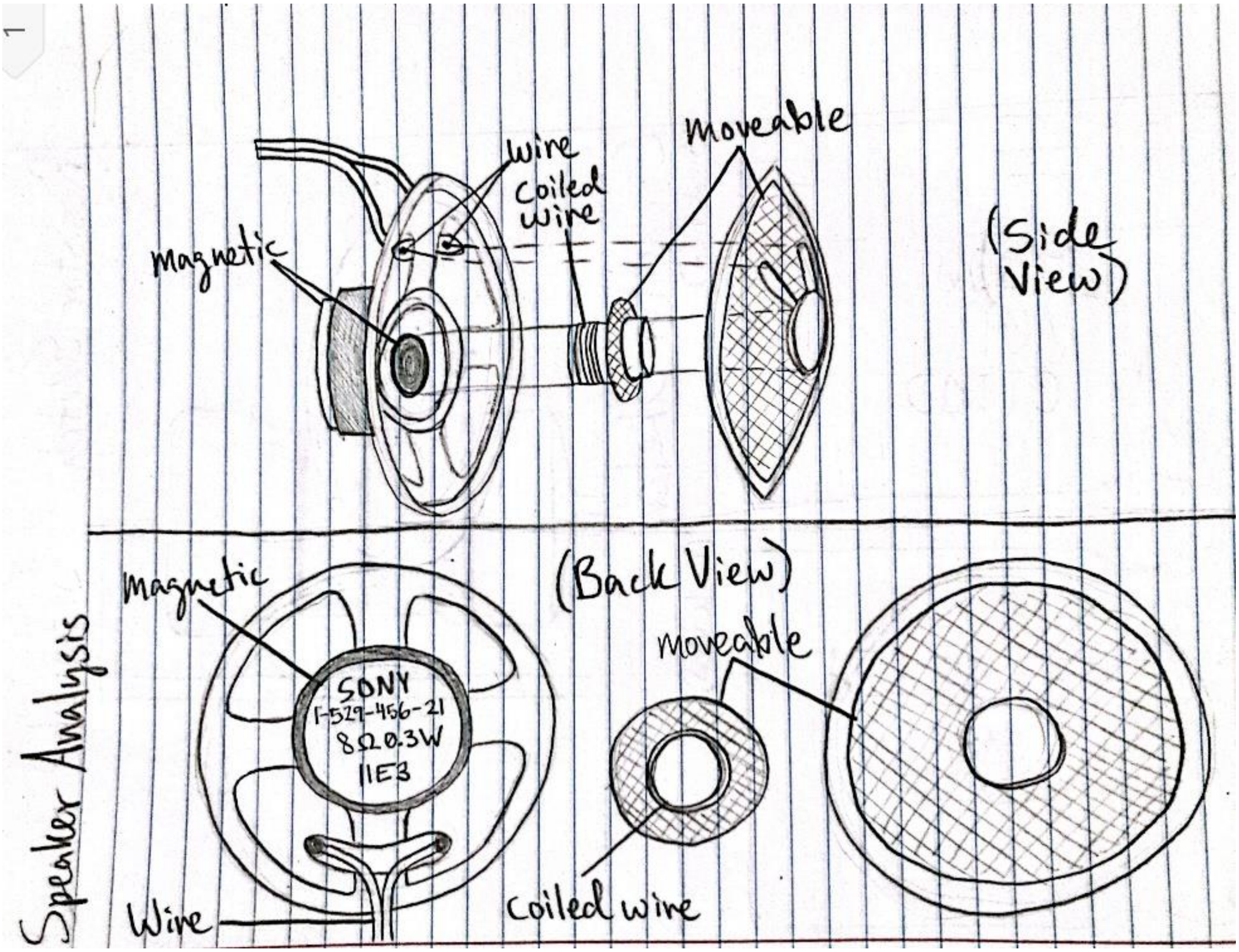
XI: Capacitor Analysis

The capacitors in my clock radios circuit came in various shapes and sizes, some even being too small to take off of the board. The capacitor that I took off and sketched here was the biggest I could find (~1/2 in. tall, ~1/3 in. diameter). This made it very easy to read and decipher the markings on it. The capacitance is indicated as 1000µF. The voltage, indicating the maximum potential difference that can safely be applied across the capacitor, is 10V. I looked up "CD110 capacitor" and found that to be the model number for the capacitor. Looking it up led me to a datasheet with tables explaining all details of the capacitor.

https://www.datasheet4u.com/datasheet-pdf/Nantung/CD110/pdf.php?id=1296682



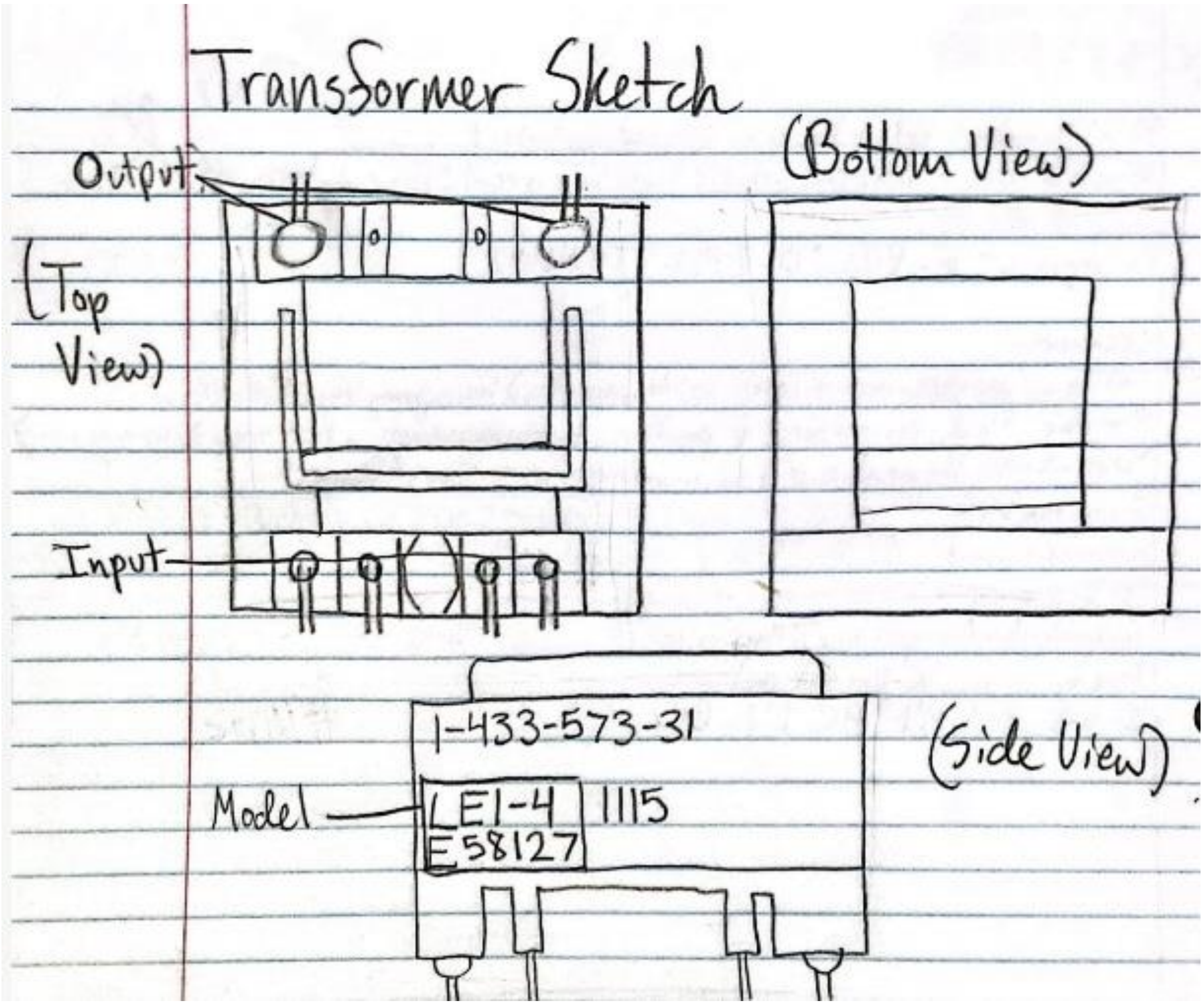
XII: Speaker Analysis



XIII: Transformer Analysis

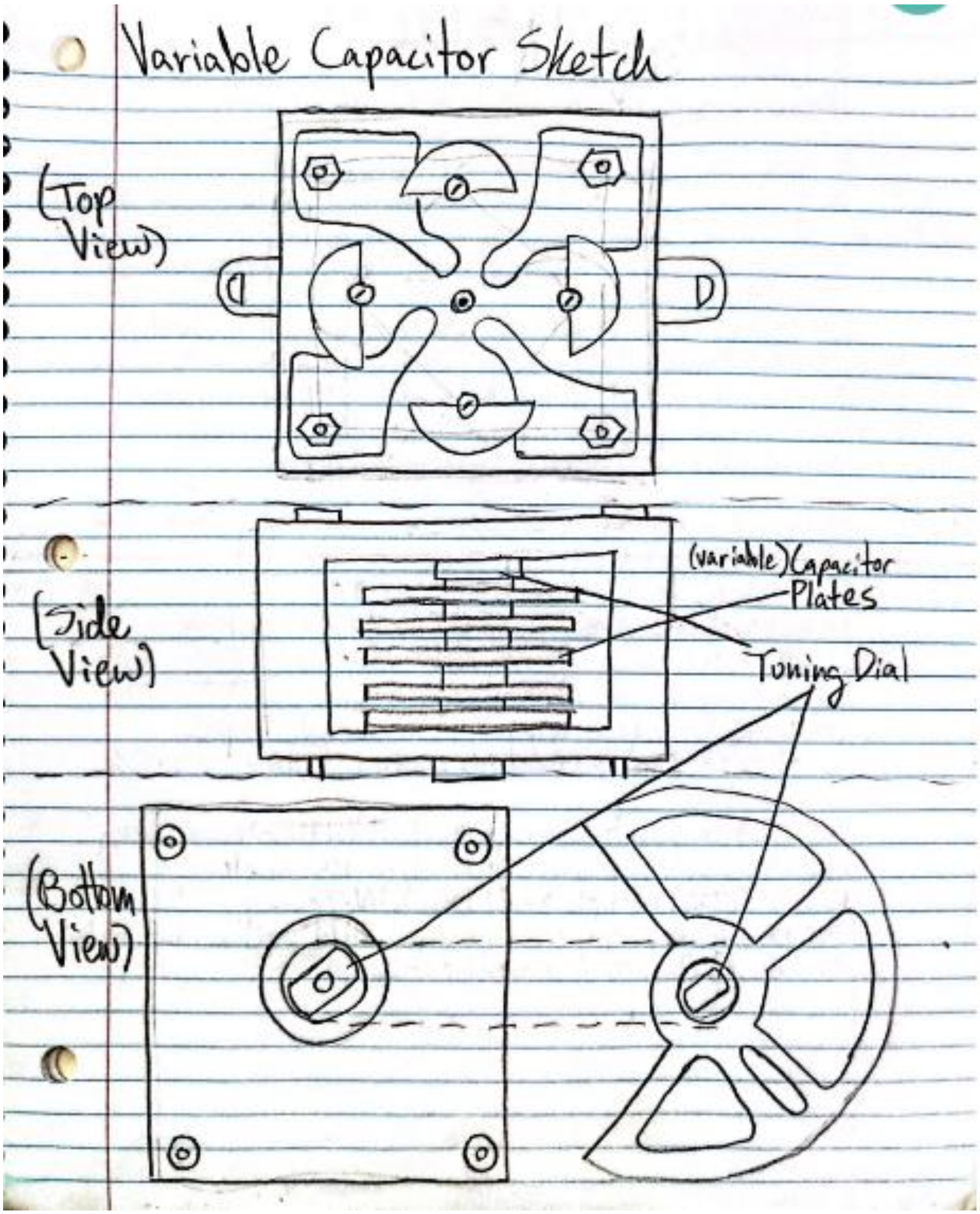
Looking up “LEI-4 E58127” led me to a datasheet explaining this model of transformer in depth.

https://www.datasheetarchive.com/pdf/download.php?id=f787d9ac02ec6e1d00d6839c704527f34cbccb&type=O&term=E58127%2520lei-4



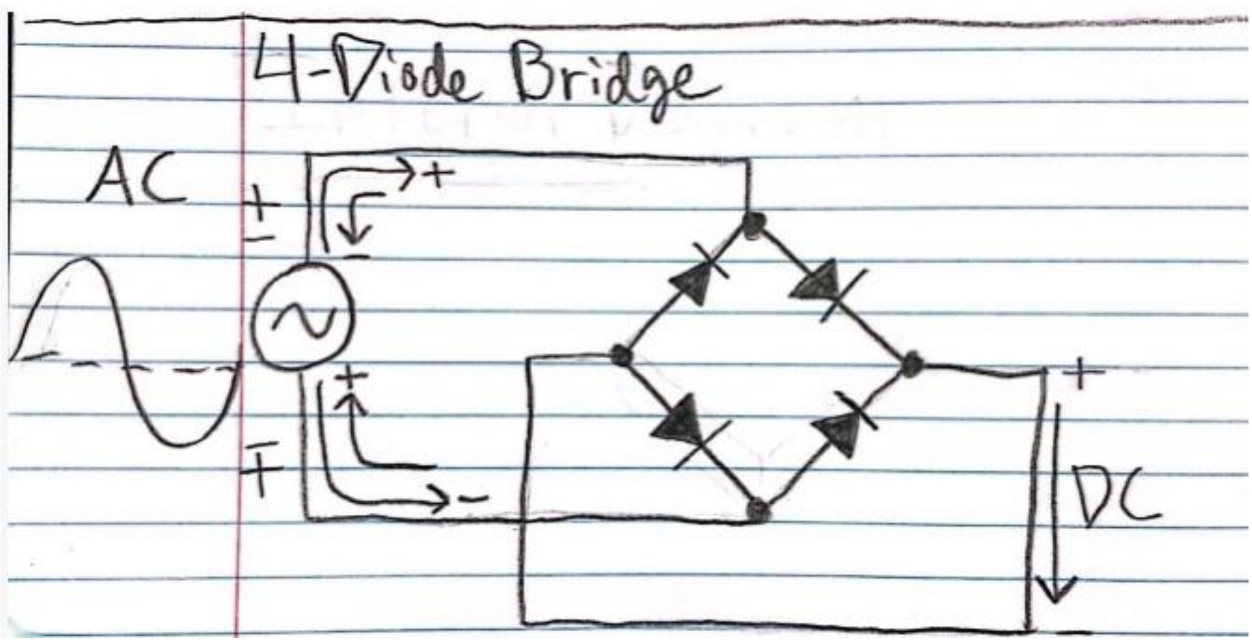
XIV: Variable Capacitor Analysis

Although I was unable to find a datasheet for this variable capacitor, taking it apart to the best of my ability allowed me to see how the capacitance is physically varied by varying the distance between the plates using the tuning dial.



XV: 4-Diode Bridge Analysis

Although the diodes in my circuit were too small to be taken off, the 4-diode-bridge is an essential component in the clock radio. It converts the alternating directional current into direct current by funneling the negative and positive components AC into diodes to control the direction of the current, leading to a common output of steady DC current.



XVI: Conclusion

I thoroughly enjoyed the simplicity and freedom provided by this project; to tear this thing apart and figure it out as much as you can. I would like to preface by saying that while I did my best to follow the lab instructions, I added extra parts along the lines of the original project. I did this to better attempt to flesh out my understanding of the components of the clock radio and express what I was able to learn. Although it was beyond the scopes of the project you assigned, any and all feedback is appreciated. :) I think this project has introduced me to new knowledge on both engineering and physics, but I think my individual learning is best furthered through deepening my understanding of the physics behind the engineering applications. I hope through this essay, I can accurately convey what I was able to learn from this process and in doing so, explain the physics of the clock radio to the best of my ability.

Considering the primary source of current is AC, the clock radio inevitably led me to learn about the applications and concept of AC current which I now understand as a sort of current wave that oscillates in magnitude and direction. The first function for AC current that I was led to is that of the transformer. To the best of my understanding, the AC current is led through a coiled wire or inductor which generates a varying magnetic field. Another inductor is placed within proximity of the field, inducing a "step down" in the magnitude of the AC current picked up by the second inductor. This process of inducing a voltage in a secondary conducting wire due to a magnetic field produced by a moving/varying (AC) current in an inductor is one example of many of electromagnetic induction. This "stepped down" current is then led to a 4 Diode Bridge which essentially transforms AC current to DC by controlling the direction which current (negative or positive) is allowed to flow using diodes. For most of the functions in the clock radio, DC current is most efficient. However, the clock and radio functions are both ran primarily on AC current. The 4-Diode-Bridge is a clever way of transforming AC into DC, but the radio has ways of reversing the process. For efficiency purposes, the clock radio contains a lithium battery backup which supports the clock output when there is no AC but is only able to do so using a crystal oscillator to create a 60Hz, alternating current.

Another application of electromagnetic induction that the clock radio uses is in the radio reception function. Radio towers/transmitting antennas use large amounts of AC current to produce a varying magnetic field. The AC current and therefore field produced has a wavelength between 10kHz-100GHz (ten thousand waves per second to one hundred million waves per second)! This is the frequency range for the radio waves that we're surrounded by all the time and familiar with in our clock radio. The receiving antenna within the radio acts as an inductor and receives a voltage from the radio tower similar to how the transformer steps down the current from the power supply. The antenna is connected to a tuning capacitor whose capacitance (distance between or cross-sectional area between the plates) is able to be manually varied via the dials on the clock. This varying capacitance changes the resonant frequency of the circuit which is tuned to match the desired frequency emitted from the transmitting antenna. The tuned signal passes through a bandpass filter which accepts frequencies within a certain range to “clean” unwanted noise from the desired signal. This tuned, filtered, variable current is led through a wire that’s free to move within the speaker. The AC current produces a varying magnetic field, and therefore leads to varying force on and position of the wire. The speaker is made with a flexible membrane that moves in tandem with the wire, creating vibrations in the air around it (sound waves!) based on the current in the wire.

One sort of conceptual breakthrough I reached was in furthering my understanding of the integrated circuit or micro-processing component in a circuit along with the physics of programming. Upon learning about electricity and magnetism, I was introduced to the idea that the binary nature of the state of a capacitor or magnet can be used to store information; a full vs empty capacitor and a long vs short magnet representing a 0 or 1. The circuit of the clock radio introduced me to integrated circuits which consist of mostly transistors that perform the same function of representing information (0s and 1s) in their binary state. This idea of millions of 0s and 1s in the form of transistors in a microchip allowed me to fill a gap and mentally reverse engineer how a computer language compiles complex ideas into binary information and how that information can be physically utilized in a circuit or computer.

I feel as though learning is the process of synthesizing the “big” and the “small”, the qualitative and the quantitative and etc. I think this project was a good learning experience for me, allowing me to see how my specified knowledge on DC voltage, capacitors, resistors, current, and electricity in general can lead to the bigger picture of the (seemingly simple) clock radio. However, the process of fitting my previous knowledge of these components into the essence of the clock radio allowed me to scratch the surface of a new bigger picture being the world of programming, engineering, and the adoption of electromagnetism as something that can be used as a tool. In short, I think it’s pretty cool that an old clock radio, a little bit of curiosity, a physics teacher who forces independence, and a little too much free time could serve as a portal to that world… so thanks!