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ELEN3081
Experiment 0
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DC Analysis

Resistor Cube

In creating a cube made up of 12 3kΩ resistors we can analyze the resistance found across two terminals at opposite corners of the cube. The cube, as seen in Figure 1, can be constructed such that the two terminals can then be connected to a source. As seen in Figure 2, when connected to a voltage source there is a resulting current running through the voltage source that can be measured.

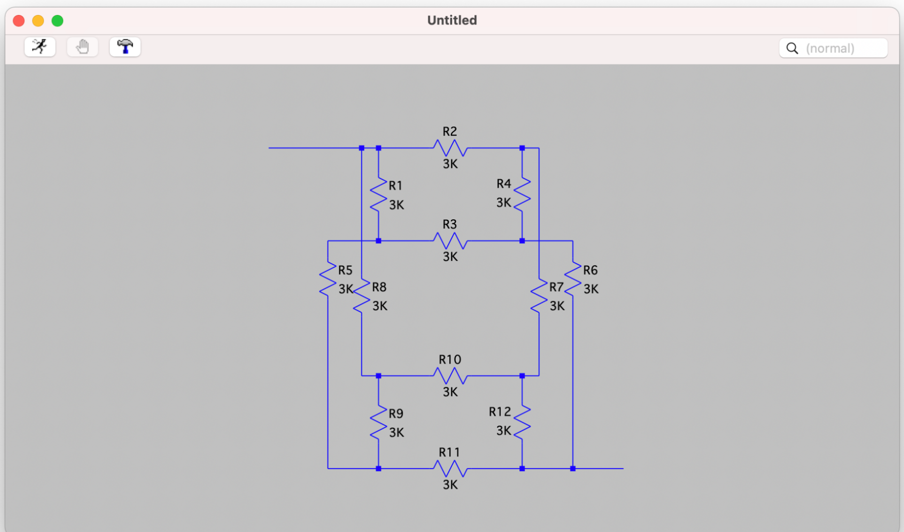
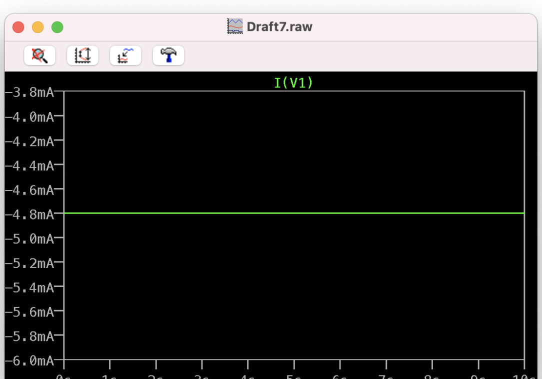


Figure 1: A cube consisting of 12, 3kΩ resistors.



With the addition of a voltage source, we can use Ohm's Law to then find the resistance between the two opposite corners. By setting the voltage source to some known value, in our case 12V, we can then measure the current through the voltage source to be 4.8mA. By simply inputting our known values into Ohm's Law, we can then calculate that the resistance between the opposite corners is 2.5kΩ. A detailed calculation can be found in Equation 1.

$$(1)\ R = \frac{V}{I} = \frac{12}{4.8} = 2.5k\Omega$$

Figure 2: The result of measuring current through the voltage source.

A similar method can be used to analyze the resistance in the opposite ends by replacing the voltage source with a current source of a known value. In the same manner, we can instead measure the voltage across the current source, insert our newfound value into Ohm's law. As seen in Equation 2, we will arrive at the same result for the resistance across the two corners of the cube.

$$(2)\ R = \frac{V}{I} = \frac{30kV}{12A} = 2.5k\Omega$$

An example of a current source connected to the cube resistor circuit can be seen in Figure 4.

Figure 3: The result of measuring voltage across the current source.

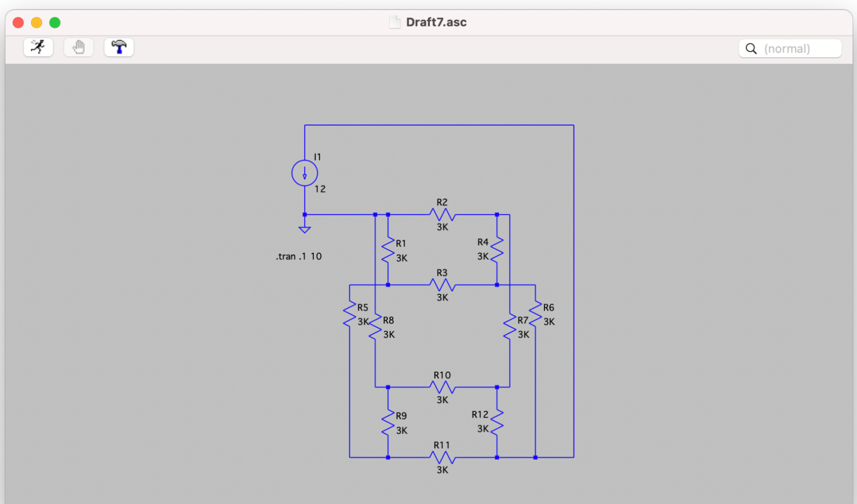


Figure 4: The cube resistor circuit connected to a current source.

Step Analysis of Power in a Resistor

When constructing a circuit we can analyze the power in a load resistor given a range of possible resistance values. When analyzing the circuit in Figure 5, we can see that there is an inverse, almost parabolic, shape with a maximum power when both resistors are equal. This is because when both resistors are equal the voltage drop on each resistor is equal. This plays a major role in determining the power that the load resistor experiences because $P = \frac{V^2}{R}$. This explains why the power plot, seen in figure 6, has a maximum power value for the load resistor when both resistors are of equal value.

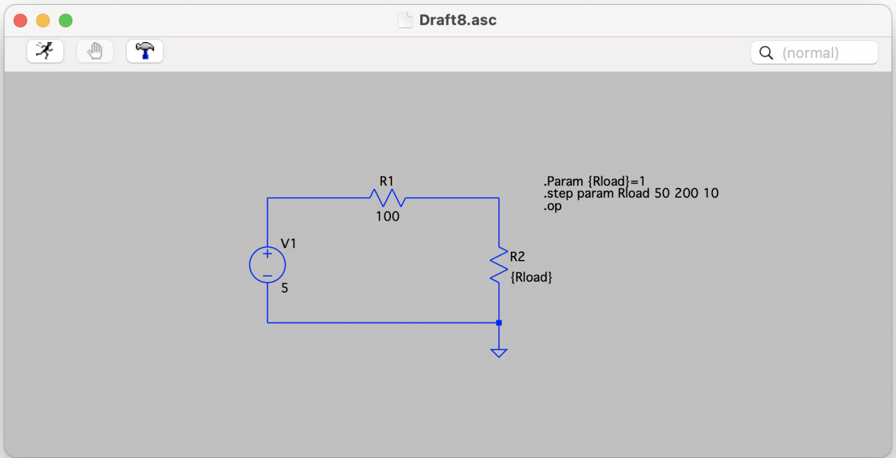


Figure 5: Two resistors in series, one resistor measured over steps from 50Ω, 200Ω.

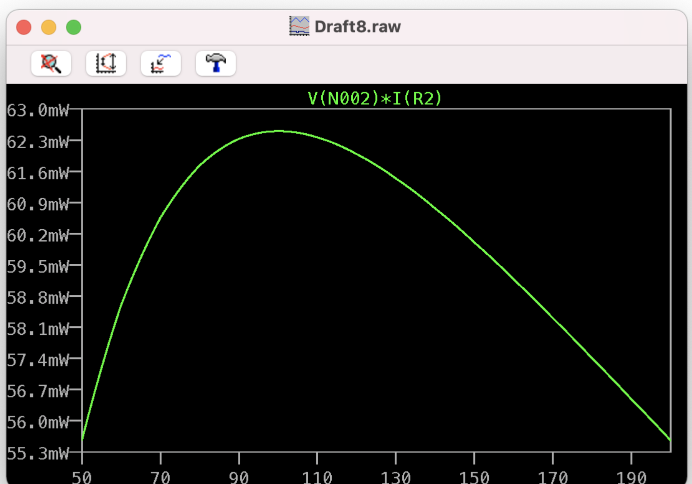


Figure 6: The power plot for the load resistor, with a maximum value at 100—when both resistors are of equal value.

DC Sweep Analysis

The DC transfer curve that can be observed in Figure 7 demonstrates that the diode protects the Vout node from reverse voltages. In essence, it acts as a one way valve, allowing positive voltages to flow through while preventing reversing. The curve demonstrates this as there is no voltage from -5V to 0V, but picks up as soon as the voltage is greater than 0V.

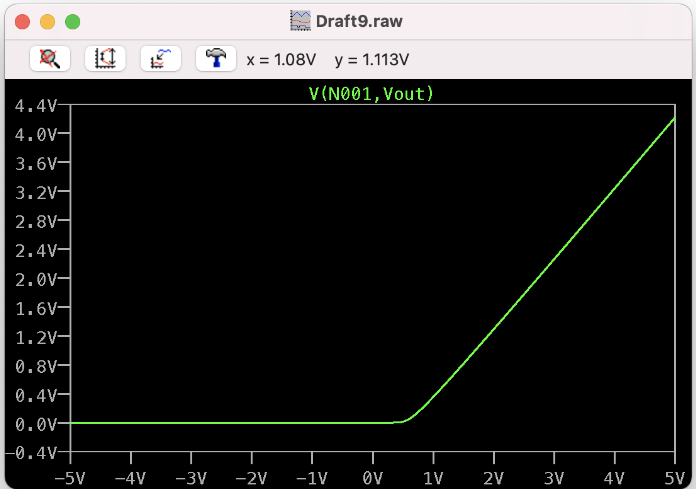


Figure 7: The diode acts as a one-way valve, only allowing positive voltage to flow through the circuit.

Transient Analysis

Fourier Distortion

When running a sinusoidal source of voltage with a non-linear load there is potential for there to be harmonic distortion. The total harmonic distortion increases as the load increases—as we can see from the analysis, when the source voltage has a peak of 0.2V the THD may be as low as 0.11%. However, when the source peak voltage is increased to 2V, the THD climbs to 25.02%. This is problematic because of the sensitivity of many of these non-linear loads, such as computers. Figure 8 shows the cycle plot with a peak voltage of 1 V and Figure 9 shows the cycle plot with a peak voltage of 2V.

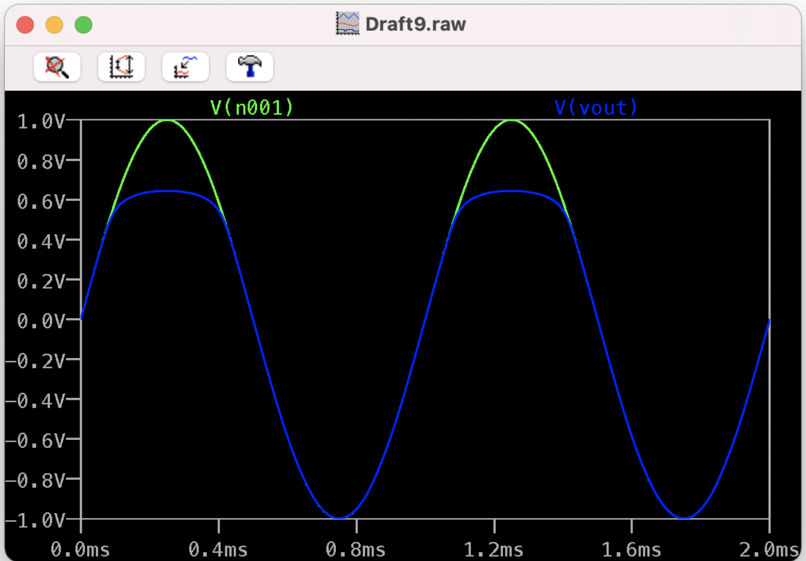


Figure 8: With a 1V peak voltage, a total harmonic distortion of 12.76% is observed.

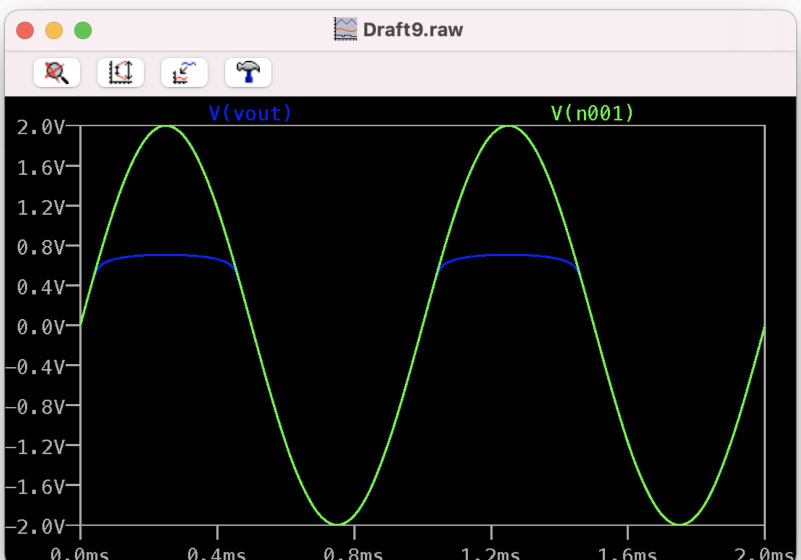


Figure 9: With a 2V peak voltage, a total harmonic distortion of 25.02% is observed.

Pulse Source with Capacitor

When running a transient analysis on this modified circuit it became clear that the time constant for this capacitor would occur when 3.15V had accumulated in the circuit. The transient analysis reveals, as can be seen marked in Figure 10, that this occurs at 0.6ns.

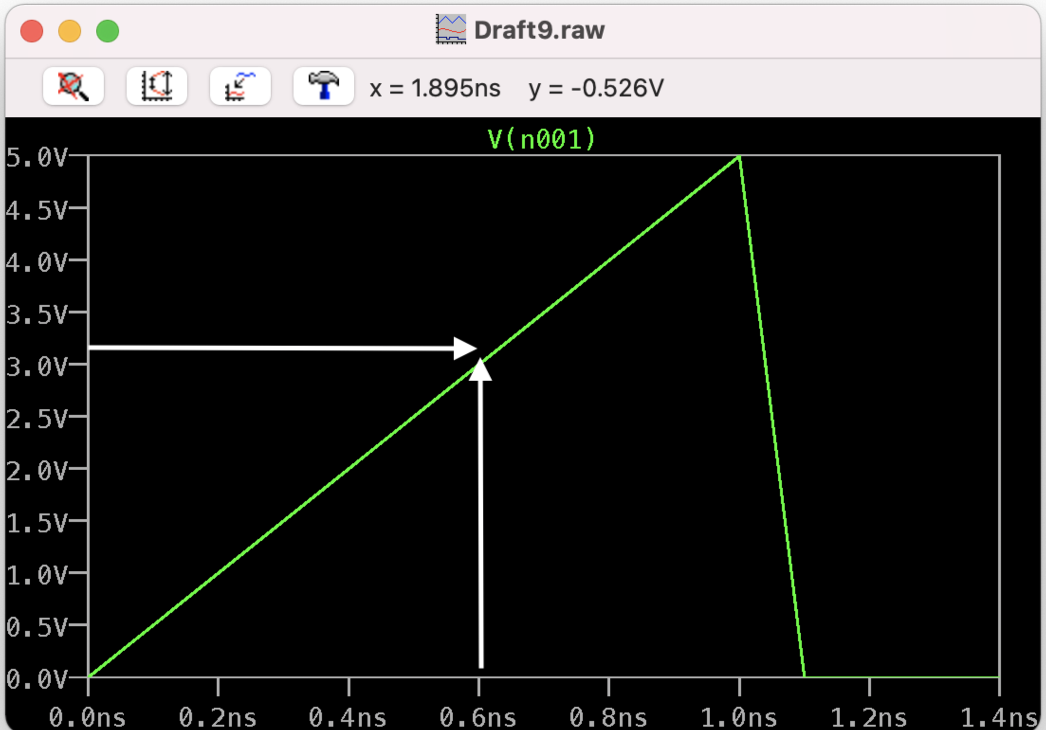


Figure 10: The time constant for this capacitor occurs when 63% of the total charge has been met—this occurs at 0.6ns.

AC Analysis

In analyzing the frequency response of this circuit, it appears that there is a constant output, as seen in Figure 11, that “jumps” around—at times not allowing for there to be an output while at other times not allowing for such an output. This is consistent over the range of frequencies, and does not seem to vary. This might be useful in sampling outputs in given times, or for providing a consistent voltage to a given load.

Figure 11: Frequency response of the AC circuit shows an almost “dashed line” but a constant output.