Tim Savas
Homework 02

Problem 1.1

Note that the voltage difference is 30V.

$$P = V^2/R$$

$$.25 = 30^2/R$$

$$.25 = 900/R$$

$$.25*R = 900$$

R = 3.6K Ohms, minimum resistance needed.

3.9K is the smallest 10% resistor you can use.

Problem 1.2

We assume that LED will pass 200mA of current. So knowing that we know that there's that current and voltage across it, you can calculate the power consumption of the resistor.

First we find the value of the resistor using Ohm's Law:

$$IR = V$$

$$R = V/I$$

$$R = 3V/.2A$$

$$R = 15 \text{ Ohms}$$

Next calculate power.

$$P = V^2/R$$

$$P = 3^2/15$$

$$P = 9/15$$

$$P = 0.6W$$

$$0.6W > .25W$$

So this won't work, sadly. Too much power being dissipated by this guy. Seems like a good scenario for a voltage divider! Let's work backward first and see what an ideal total resistance would be:

$$P = V^2/R$$

$$.25 = 9/R$$

$$.25R = 9$$

$$R = 36 \text{ Ohms}$$

We would like a total resistance that is at least 36 Ohms.

So now I believe we can use our equation do figure out two good 10% resistor values that when in parallel render 36Ohms:

$$R_{total} = R_1 \mid\mid R_2$$

$R_{total} = (R_1*R_2)/(R1+R_2)$[1][2]

38 Ohms = (47*220)/(47+220) this is true

38Ohms > 36Ohms

R1 = 47Ohms || R2 = 220Ohms

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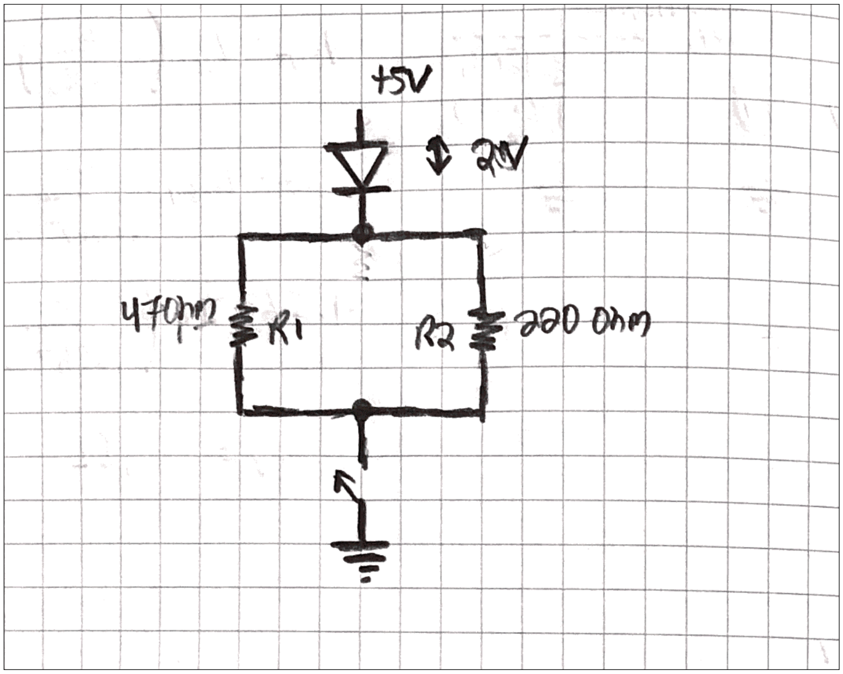
[1] My own study reference is here for these calculations.

[2] This also seemed like a good article to review and look at.

And here is the circuit diagram showing R1 || R2:



<u>So this answer is wrong!!!!</u>

If you're limited to .25W resistors and you have to dissipate .6W you will need at least three Rs!

Take .6W divid by 3

p = IV

Once you decided to use three resistors

using a quarter watt resistor

*.25 = I*3*

Figuring out I for a .25W resistor

that's the max current: 83.3mA

you take 200mA divide by 3 so I = 66.6 mA

Solve for resistance

So each resistance needs to pull 66.6mA

There are many ways to solve this problem, since it's not asking for the minimum number of resistors. I need to enter class. Out of time!

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Problem 2

So we can start with either 120V or 240V, and we're competing with a specific voltage drop for those. After their respective voltage drops, are we still getting enough voltage to meet the nominal required voltage?

I have done the math out in the table. The answer is that the 14-gauge cable does work and we do not have to install a new 16-gauge cable. Meanwhile, running it at either 120V or 240V will work. There is less voltage drop with the 240V, so I presume it's best to run it at 240V on the 14-gauge, since there would be an energy and cost savings from less energy being lost to heat.

Cable	Voltage Source (V)	Voltage Drop (V)	Resulting Voltage (V)	Nominal Voltage Required (V)	Is Resulting V > Nominal Required V?	Does this require a new cable?	So do we need a new cable in the ground?
14 Gauge	120	89%	106.8	100	Yes, it works.	No	No, the 14 gauge works.
14 Gauge	240	89%	213.6	200	Yes, it works.	No	
16 Gauge	120	93%	111.6	100	Yes, it works.	Yes	
16 Gauge	240	93%	223.2	200	Yes, it works.	Yes	

Problem 3

I will create a Thevenin model of the resistors first.

Let's find V_{out} first. aka V_{thev}

$$V_{out} = V_{in} \text{ x } (R_2/R_1+R_2)$$

$$V_{out} = 10V \text{ x } 1K/11K$$

$$V_{out} = 0.91V$$

$$V_{thev} = 0.91V$$

I've written the equation here, but you can say "what is 1/11th of 10V?"

Now we figure out R_{thev}

$$R_{thev} = R_1 \mid\mid R_2$$

$$R_{thev} = (R_1 * R_2)/(R1+R_2)$$

$$R_{Thev} = .91K$$

This gets back to our rule: In a parallel circuit, a resistor much smaller dominates. And here we see that: R_{thev} almost equals the comparably smaller R_2

Let's calculate the total capacitance now. Off the bat we can see that the 100pF is negligible because it is 1/1000 the value of the other capacitor. I'll prove it just for my own sanity:

For the two capacitors, we can reduce them down to one single equivalent capacitor by adding them, since they're in parallel.

$$C_{eq} = C_1 + C_2$$

$$C_{eq} = 0.1\mu F + 100pF$$

$$C_{eq} = .1001\mu F$$

Yep, that tiny capacitor is negligible considering our rule. Let's get rid of it and say $C = 0.1\mu F$

We can do the RC equation now:

$$\text{time-constant} = RC$$

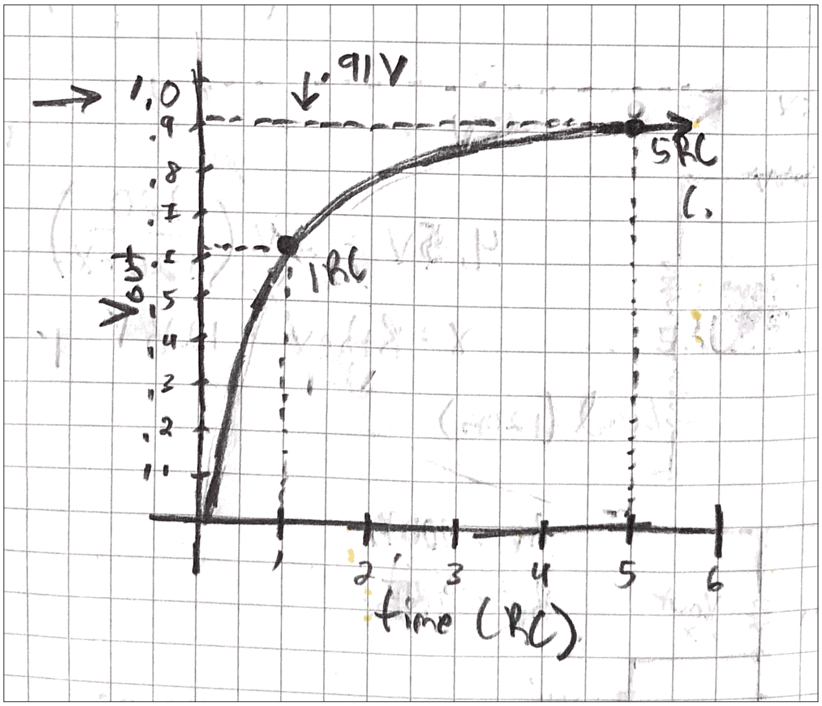
$$\text{time-constant} = .91K \text{ x } .1\mu F$$

$$\text{time-constant} = 91\mu s$$

So now we can draw a few points on the curve that shows after the switch is closed:

- one RC, 91μs, Vcap goes 63% of the way toward its destination, which is .91V
  - so 1RC @ .57V
- five RCs, 455μs, Vcap goes 99% of the way toward its destination, which is .91V
  - so 5RC @ .90V

Let's party!



*Note in my drawing that the .91V is the asymptote. My curve does not touch the asymptote. Hard thing to draw, so I thought I'd write that here.

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Problem 4.1

I break this down into a few steps:

1. Create a Thevenin model for everything left of the switch
2. Calculate the total resistance of the two resistors in parallel on the right
3. Make a Thevenin model from that, assuming switch closed.
4. Add the capacitances, since they're in parallel

First I will create a Thevenin model of everything left of the switch.

Let's create V_{out} first. aka V_{thev}.

$$V_{out} = V_{in} \times (R_2/R_1+R_2)$$

$$V_{out} = 20V \times (4K/10K)$$

$$V_{out} = 8V$$

$$V_{thev} = 8V$$

I've written the equation here, but you can say "what is ⅖ of 10V?"

Now we figure out R_{thev}:

$$R_{thev} = R_1 \mid\mid R_2$$

$$R_{thev} = (R_1*R_2)/(R_1+R_2)$$

$$R_{thev} = (4K*6K)/(4K+6K)$$

$$R_{Thev} = 2.4K$$

I will also calculate the total resistance of the two resistors in parallel to the right of the switch. I hesitate to call this another R_{thev}. It's not tied to a Voltage source, so we're not really making a new Thevenin model. We just want to get the total resistance.

$$R_{total} = R_1 \mid\mid R_2$$

$$R_{total} = (R_1*R_2)/(R1+R_2)$$

$$R_{total} = (1.6K*4K)/(1.6K+4K)$$

$$R_{total} = 1.1K$$

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Once the switch closes, we get a voltage across both R_{thev} and R_{total}, so in my view this can be abstracted into a Thevenin model itself. Let's do it.

Here are our parameters:

Vin = 8V

R1 = 2.4K

R2 = 1.1K

$$V_{out} = V_{in} \times R_2/(R_1+R_2)$$

$$V_{out} = 8V \times 1.1K/(1.1K+2.4K)$$

$$V_{out} = 2.51kV$$

$$V_{thev} = 2.51kV$$

Now we figure out R_{thev} again:

$$R_{thev} = R_1 \,||\, R_2$$

$$R_{thev} = (R_1 * R_2)/(R_1+R_2)$$

$$R_{thev} = (2.4K*1.1K)/(2.4K+1.1K)$$

$$R_{Thev} = 750 \text{ Ohm}$$

Lastly we must abstract out the two capacitors into one capacitor. They are in parallel, so the capacitances just add together:

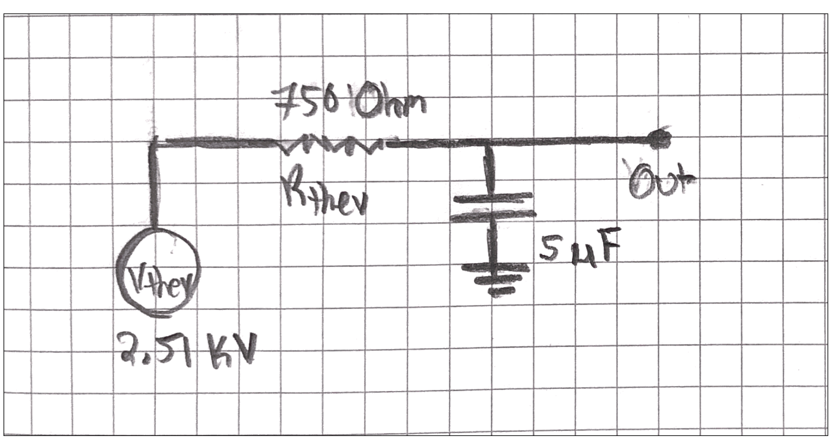
$$C_{total} = C_1 \,||\, C_2$$

$$C_{total} = C_1 + C_2$$

$$C_{total} = 4.5\mu F + 500nF$$

$$C_{total} = 5\mu F$$

We now have the Thevenin model driving a single capacitor, after the switch is closed. Here is the drawing:



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Problem 4.2

RC = 750 Ohm * 5μF

RC = 3.75ms

1RC calculation

63% of V_{cap}

2.51kV * .63

1.58kV @ RC, 3.75ms

5RC calculation

99% of V_{cap}

2.51kV * .99

2.48kV @ 5RC, 18.75ms

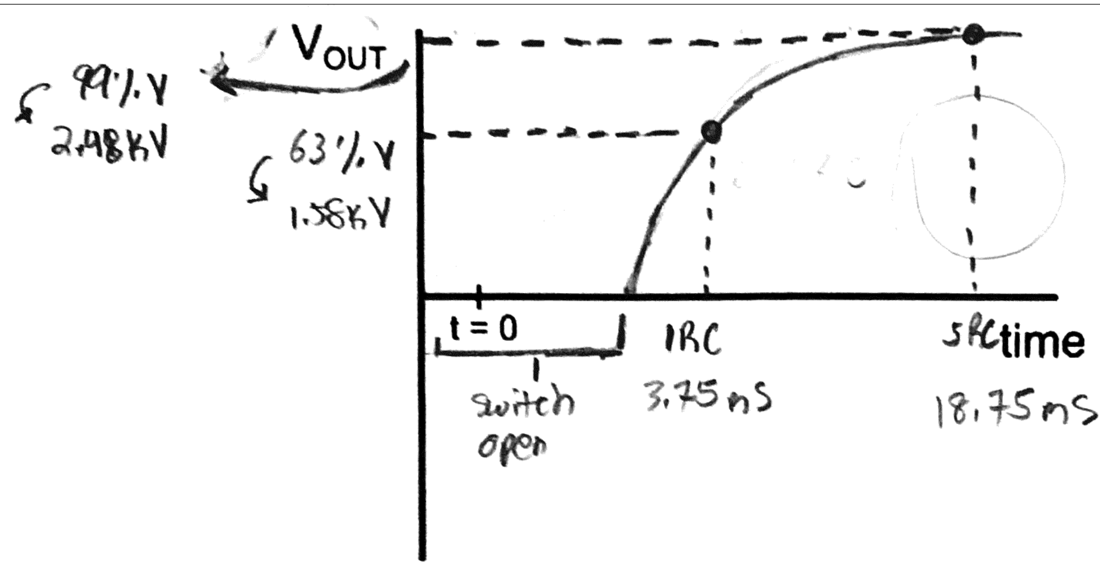

Figure 5: Time domain plot, just after closing of switch

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Problem 5.1

dB	Amplitude Ratio
6	2/1
-6	1/2
3	$\sqrt{2}$
-3	$1/\sqrt{2}$
-20	0.1
60	1,000
100	10,000

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Problem 5.2

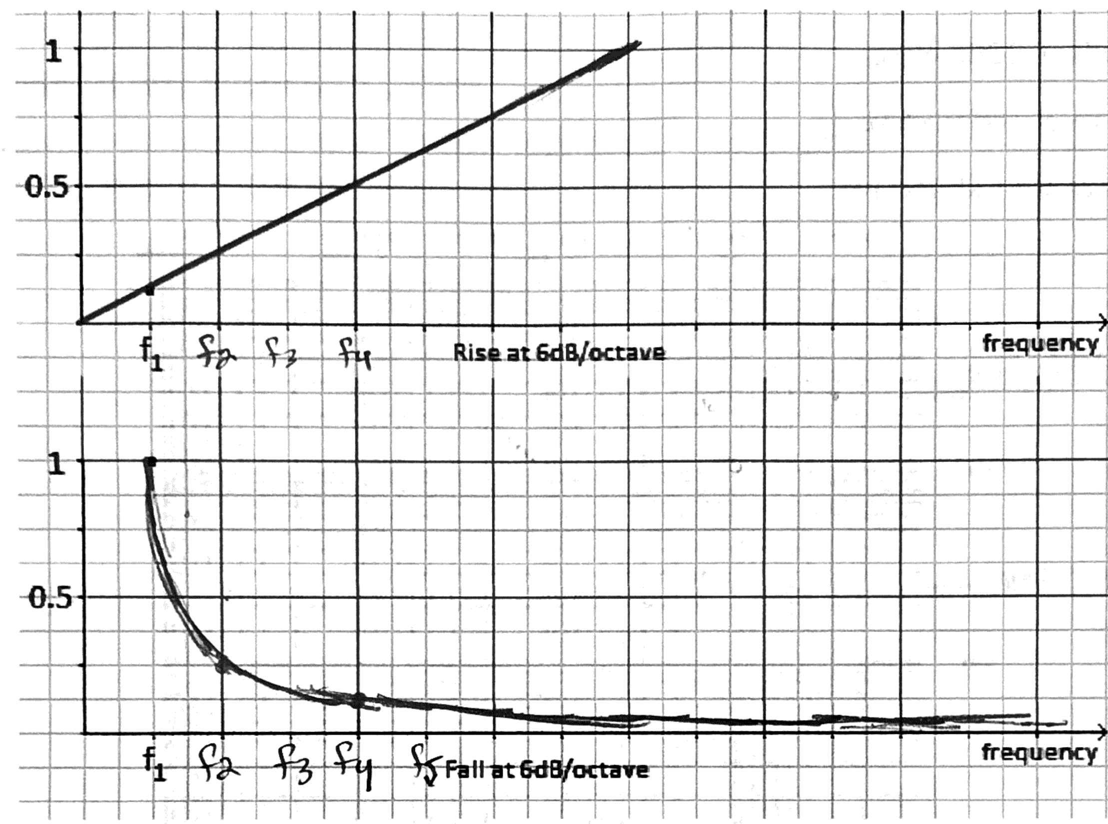

Figure 6: rise at 6dB/octave, fall at -6dB/octave

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Problem 5.3

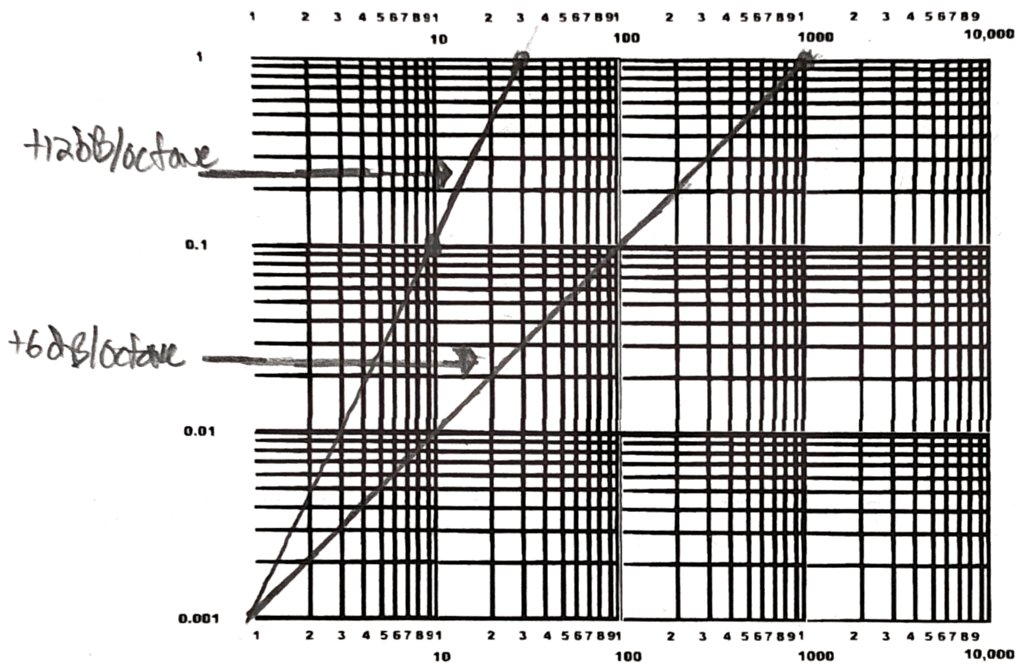

Figure 7: Log-Log plot: rise at 6dB/octave, and at 12dB/octave

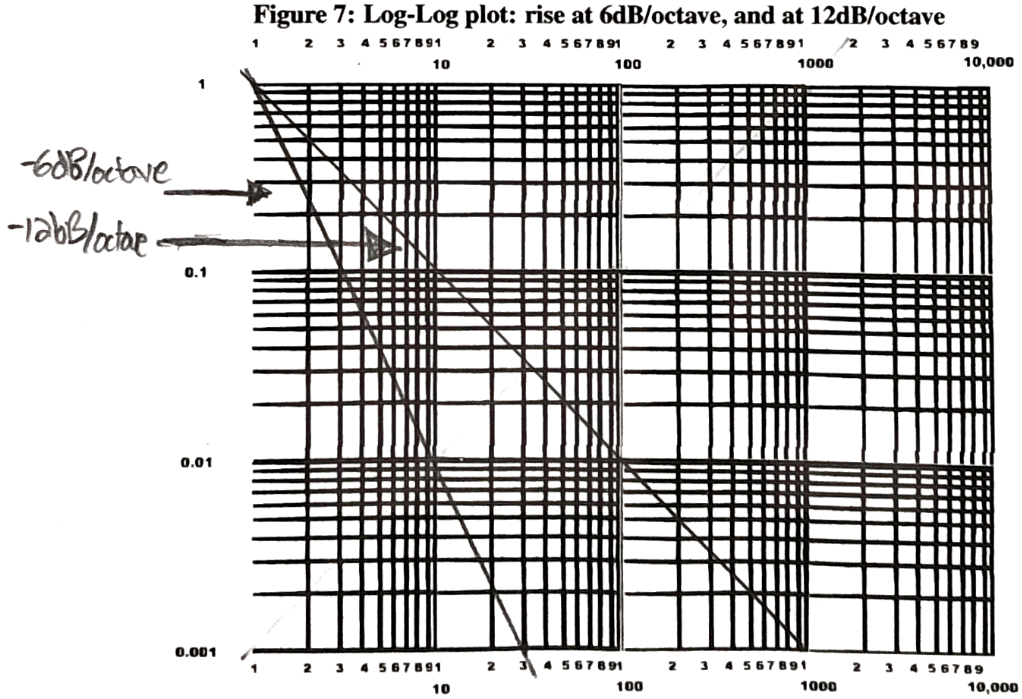

Figure 8: Log-Log plot: fall at -6dB/octave, and at -12dB/octave

hw2_sept17xa.tex; September 11, 2020