Lab 5 report

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Black box: Charles Darwin (box with 4 components)

1. Measurements

1.1. Resistance[1]

Green-Red	∞Ω (increasing)
Green-Black	∞Ω (increasing)
Red-Black	0Ω
Green-Red with short-circuited Red-Black	∞Ω (increasing)
Green-Red with short-circuited Green-Black	0Ω
Green-Black with short-circuited Red-Black	∞Ω (increasing)
Green-Black with short-circuited Red-Green	0Ω
Red-Black with short-circuited Green-Black	0Ω
Red-Black with short-circuited Red-Green	0Ω

1.2. Voltage measurement with DC[2]

The measurement was done with 5Vpp, offset 1V.

1. Source with 1k resistor are connected to Green and grounded in Red. Measured over 1k resistor. Frequency is 5Hz.	Voltage from the source is 6V. Maximum voltage over the resistor is 374.866mV and is decreasing and goes to 0. tau is at the point 374.866mv*(1-0,63)=138.7mV, which is 13.04ms
2. Source with 1k resistor are connected to Red and grounded in Black. Measured over 1k resistor.	Voltage from the source is 6V. Measured voltage at the start is 5.375V, then in increases to 6V. ΔV=6-5.375=0.625V. tau is at the point 625mv*0,63=394mV, which is 465µs.
3. Source is connected to Green and grounded in Black. Measured over 1k resistor between Red and Black.	Voltage from the source is 6V. Maximum voltage over the resistor is 42.3mV and is decreasing and goes below 0. tau is at the point 42.3mv*(1-0,63)=15.651mV, which is 425µs
4. Source is connected to Red and grounded in Black. Measured over 1k resistor Green and Black.	Voltage from the source is 6V. Maximum voltage over the resistor is 373mV and is decreasing. tau is at the point 373mv*(1-0,63)=138mV, which is 13.2ms
5. Source with 1k resistor are connected to Green and grounded in Black with short-circuited Red-Black. Measured over 1k resistor.	Voltage from the source is 6V. Maximum voltage over the resistor is 374.4mV and is decreasing. tau is at the point 374.4mv*(1-0,63)=138.5mV, which is 13.07ms
6. Source is connected to Red and grounded in Black with short-circuited Green-Black. Measured over 1k resistor.	Voltage from the source is 6V. Measured voltage at the start is 5.375V, then in increases to 6V. ΔV=6-5.375=0.625V. tau is

[1] 1kΩ resistor was used for measurement, so all results are VALUE-1000

[2] AC current with square waveform

	at the point 625mv*0,63=394mV, which is 465µs.

1.3. Voltage measurement with AC

The measurement was done with 5Vpp, offset 1V, frequency in interval between 10Hz and 1MHz and 1kΩ resistor.

Source is connected to Red and grounded in Black. Measured between Green and Black.

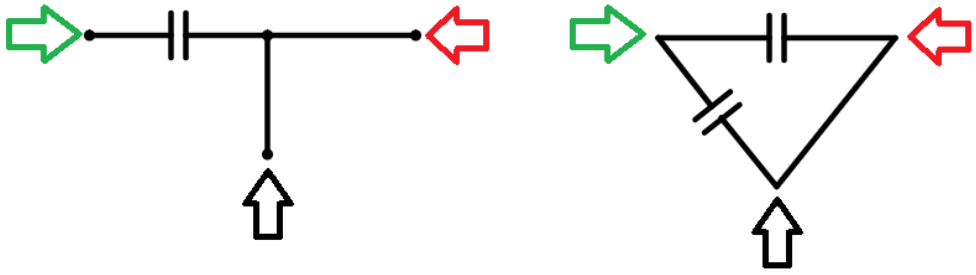
	Source is connected to Green and grounded in Black. Measured between Red and Black.		*Source with 116Ω resistor is connected to Red and grounded in Black. Measured over the resistor.*	
Frequency	**V_{source}**	**$V_{measured}$**	**V_{source}**	**$V_{measured}$**
10	10	01.204m	10	9.991
50	10	09.460m	10	9.774
100	10	18.955m	10	9.209
500	10	61.771m	10	5.882
1k	10	73.599m	10	5.202
5k	10	79.099m	10	4.928
10k	9.969	79.288m	10	4.918
50k	9.966	79.258m	10	4.915
100k	9.966	79.364m	10	4.915
500k	9.930	79.350m	10	4.912
1M	9.810	79.351m	10	4.909

Maximum measured voltage between Red and Black is 74.442mV. It means the breaking point is 79.351m*0.707= 56.101mV. This voltage accurses when frequency is 139 Hz.

Maximum measured voltage over the resistor is 9.991V and minimum is 4.909V, so the difference is 5.082. It means the breaking point is 5.082*0.707+5.082=8.675V. This voltage accurses when frequency is 362 Hz.

2. Analysis

1. Based on resistance measurements, the only known is that the circuit has at least one capacitor that is connect in some following way:



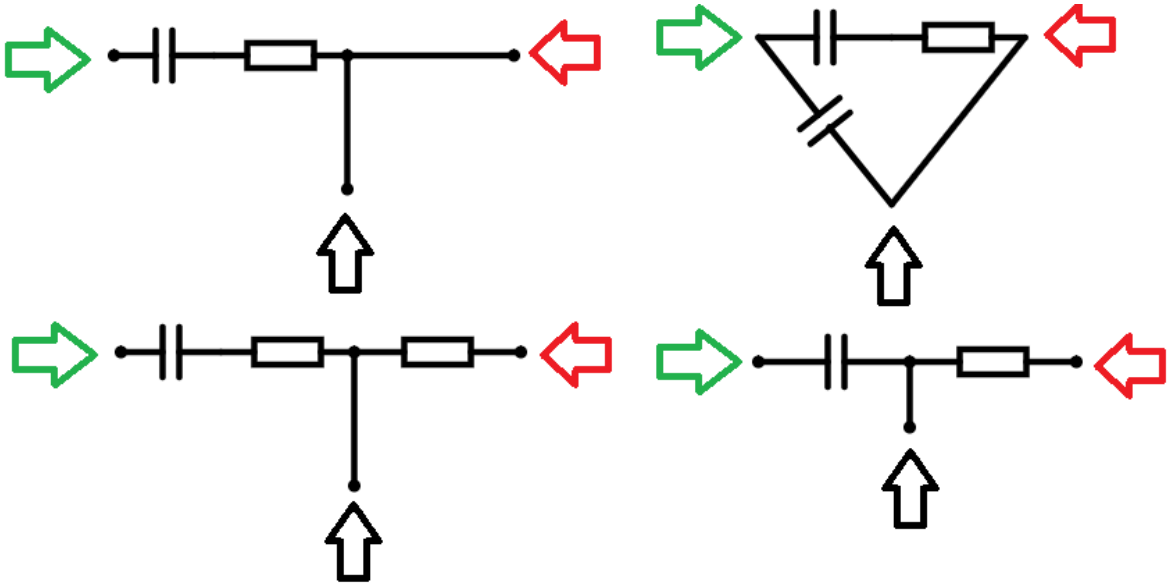
2. Based on the first observation with DC, there is a capacitor between Green and Red, because voltage over the resistor decreases. Since maximum value of observed voltage is 374.866mV, it means that there is an additional resistance. We can calculate this value as proportion between voltage over the resistor compared to total voltage with its total resistance:

$$\frac{1k\Omega}{R_{total}} = \frac{374.866mV}{6V} \text{ or } R_{total} = \frac{6}{0.374866} \cdot 1k = 16.006k\Omega$$

At the same step we can learn the value of the capacitor:

$$\tau = RC \text{ or } C = \frac{\tau}{R} = \frac{13.04m}{16.006} = 815\text{nF}$$

The resistor with 1kΩ is connected in series, which means that between Green point and Red point there is a resistor with 15.006k (or most likely 15k). It can be one resistor or several that such total resistance. So schematically we can have following:

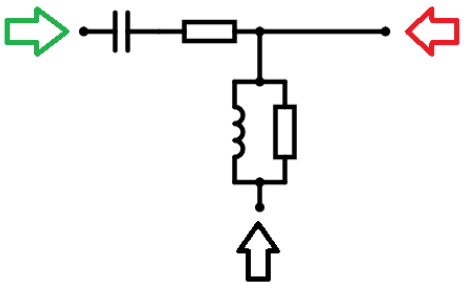


3. Based on the second observation from DC, we know that there is a capacitor because voltage over the resistor is increasing, and there is a resistor parallel to capacitor because voltage at the beginning that disappears over time. We can learn again total resistance:

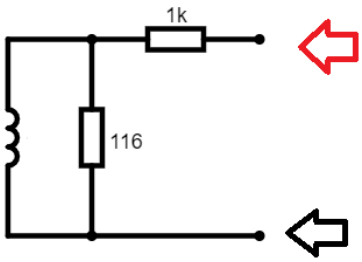
$$\frac{1k}{R_{total}} = \frac{5.375}{6} \rightarrow R_{total} = \frac{6}{5.375} \cdot 1k = 1.116k\Omega$$

The resistor with 1kΩ is connected in series, which means that between Red point and Black point there is a resistor with 116Ω (and it is parallel to the inductor).

4. We know that there can be four components: minimum one capacitor between green and red, minimum one resistor between green and red, one inductor with parallel resistor between red and black. Which means there can be only one possible combination, and we know all values except the inductor:

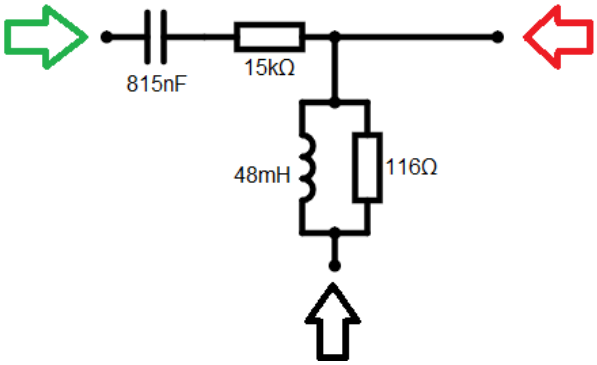


5. Analysing measurement 6 with DC means that we are looking on following circuit:



To calculate inductance based on time constant we need to know right resistance, which is R_{Th}. In this case it will be short-circuited between Red and Black, so resistors are in parallel with R=1000//116=103.94Ω. Since $\tau = {}^{L}/_{R}$, then $L = \tau \cdot R = 465\mu \cdot 103.94 = 48\text{mH}$.

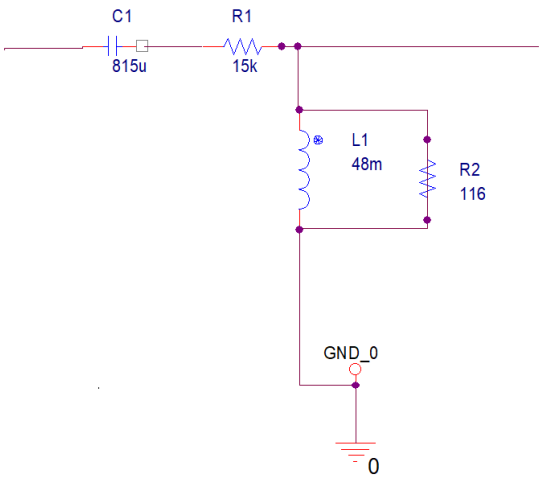
Hence the final circuit looks like this:

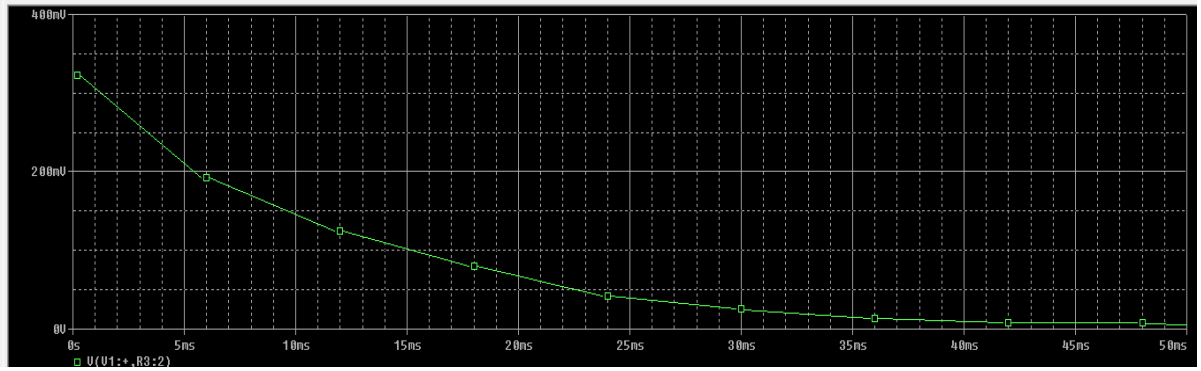


All calculations were done with just DC, which means all calculations with AC were not used.

3. Simulation

A model was built in OrCAD and the first measurement with DC voltage source was repeated as seen below:


C1
815u
R1
15k
L1
48m
R2
116
GND_0
0


400mV
200mV
0V
0s
5ms
10ms
15ms
20ms
25ms
30ms
35ms
40ms
45ms
50ms
V(V1:+,R3:2)