

1909754

by Jason Sanger

FILE	15128_JASON_SANGER_1909754_175211_1123764895.PDF (597.87K)		
TIME SUBMITTED	13-JAN-2020 01:20PM (UTC+0000)	WORD COUNT	2590
SUBMISSION ID	118161049	CHARACTER COUNT	14907

Level 4 Electrical and Electronic Principles

Assignment – Investigate into DC Transient

Course:	HNC Electrical and Electronic Engineering
Module:	SGEE4000 – Electrical and Electronic Principles
Assignment Title:	Investigation into DC Transients
Name:	Jason Sanger
University number:	1909754
Date Submitted:	13/01/2020
Word Count:	2166 words

Executive Summary

This report is going to explain how R-L and R-C circuits will behave when connected to a voltage source. It has been viewed through three different methods to then come to this outcome. The three methods used are a practical test which means the circuit was genuinely made and then monitored with a multimeter. The second method of proving is using the maths equations such as the exponential equations for charge and discharge of current in a capacitor. Finally the third way of proving is done using a program called NI Multisim which is a computer simulated circuit builder.

Contents

Executive Summary.....	1
Task 1 and 2	3
Task 1 and 2 practical.....	4
Task 1 and 2 practical results	5
Task 1 and 2 maths	8
Task 1 and 2 Multisim	10
Task 3	12
Task 3 Multisim	13
Task 3 Maths	14
Task 4	15
Task 4 Maths	15
Task 4 Multisim	16
Background Knowledge	18
Tau	18
Conclusion.....	18
Task 1 and 2 conclusion	18
Task 3 conclusion	19
Task 4	19

Task 1 and 2

Task 1 was an RC circuit which stands for resistor and capacitor circuit, it contained a $5.6\text{k}\Omega$ Resistor, $10,000\mu\text{F}$ Capacitor and a 6V DC Power supply. The circuit looked like this:

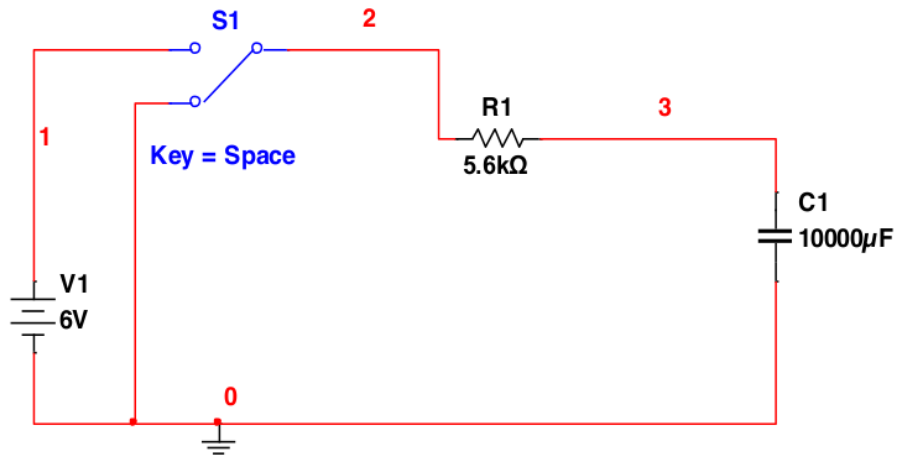


Figure 1#

Task 1 and 2 practical

The task at hand was to use three different methods to find results of the voltage and current across a capacitor as it charged and discharged. The three methods used to carry this out were a practical, multisim and then using the maths equations to work it out.

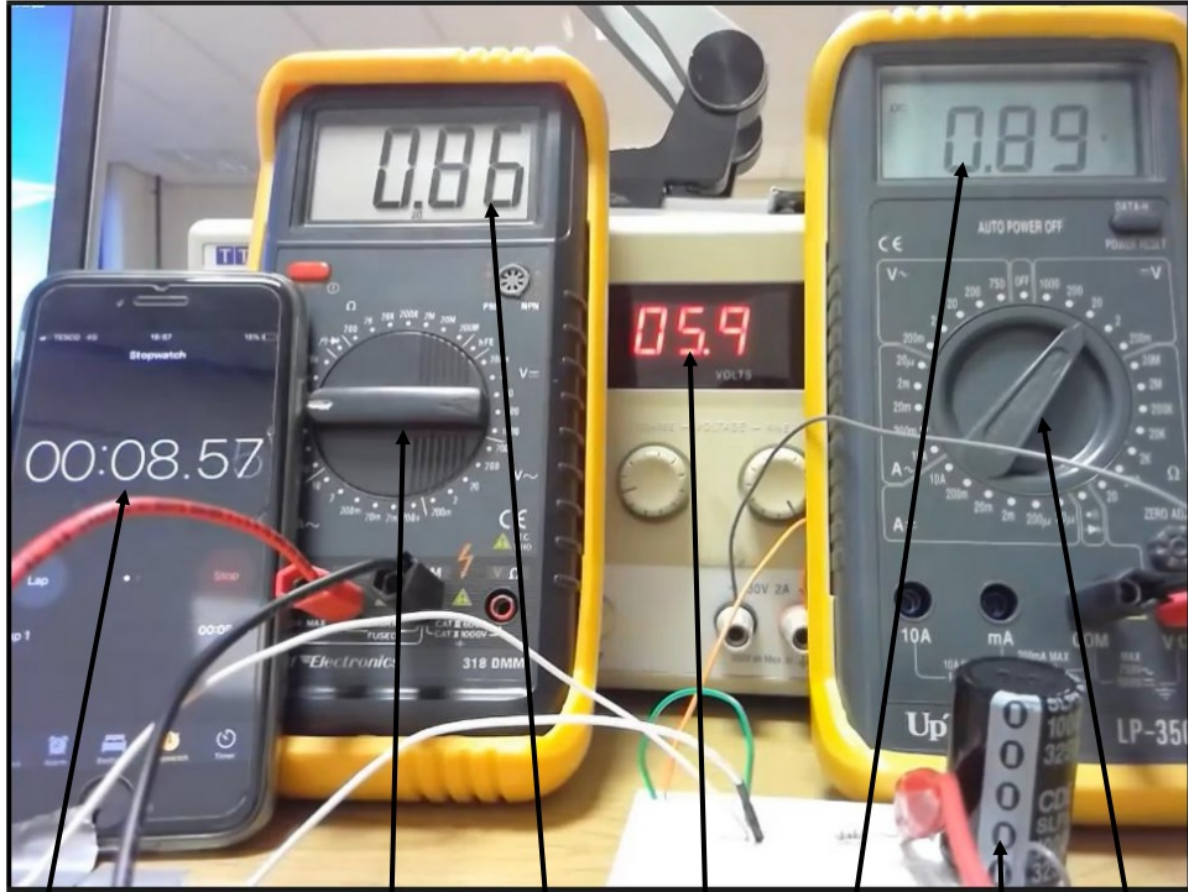


Figure 2

This is a timer to record how long the capacitor had been charging

This is the multimeter set to DC voltage

This is the screen that outputs the DC voltage being read by the multimeter

This is the screen that outputs the DC voltage being read by the multimeter

This is the multimeter set to current

This is the voltage supply being used you charge the circuit

This is the capacitor that is being measured to track charge and discharge

Task 1 and 2 practical results

The practical task was recorded as it was then possible to pause the circuit at different time intervals and record the current and DC voltage across the capacitor. The different time intervals chosen were five seconds apart for one minute, ten seconds apart for the second minute then a further thirty seconds apart for the last three minutes. These are the results received for the voltage and current across a capacitor as it charged and discharged

Charge

Time	Current	Voltage
0	1.07	0
5	0.92	0.54
10	0.84	1.04
15	0.77	1.49
20	0.7	1.86
25	0.64	2.21
30	0.59	2.55
35	0.54	2.84
40	0.49	3.13
45	0.45	3.39
50	0.41	3.61
55	0.38	3.82
60	0.35	4
70	0.29	4.34
80	0.24	4.62
90	0.21	4.85
100	0.17	5.05
110	0.15	5.21
120	0.12	5.35
150	0.07	5.65
180	0.04	5.83
210	0.03	5.93
240	0.02	5.95
270	0.01	6.03
300	0.01	6.06

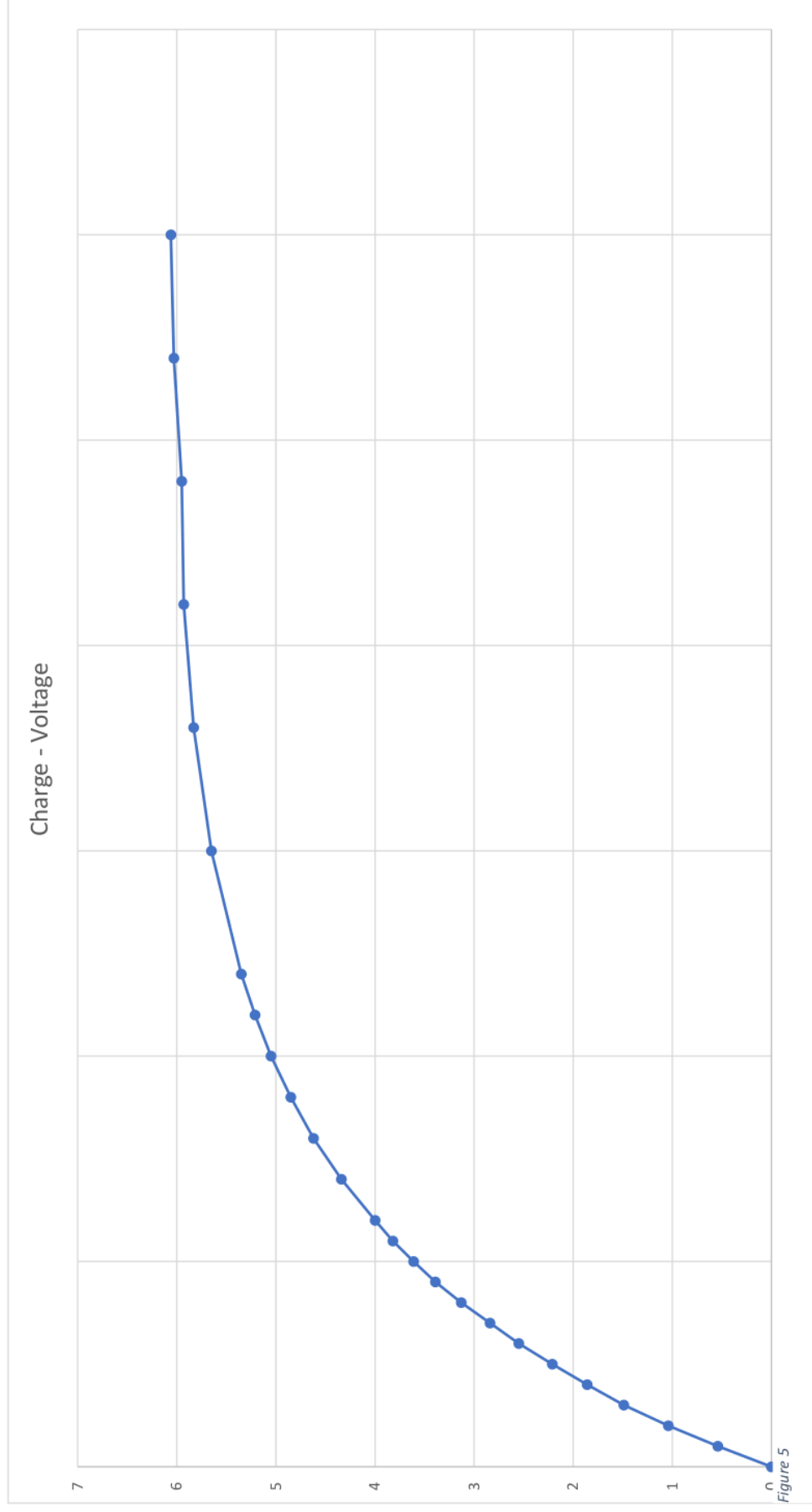
Figure 3

Discharge

Time	Current	Voltage
0	-1.07	6.06
5	-0.92	5.52
10	-0.84	5.07
15	-0.77	4.65
20	-0.7	4.24
25	-0.64	3.9
30	-0.59	3.56
35	-0.54	3.27
40	-0.49	2.98
45	-0.45	2.74
50	-0.41	2.5
55	-0.38	2.2
60	-0.33	2.1
70	-0.29	1.76
80	-0.24	1.48
90	-0.2	1.24
100	-0.17	1.05
110	-0.14	0.88
120	-0.12	0.74
150	-0.07	0.44
180	-0.04	0.27
210	-0.02	0.16
240	-0.01	0.1
270	0	0.06
300	0	0.04

Figure 4

The results from these tables were then put into graphs using Microsoft excel and shown below



Charge - Current

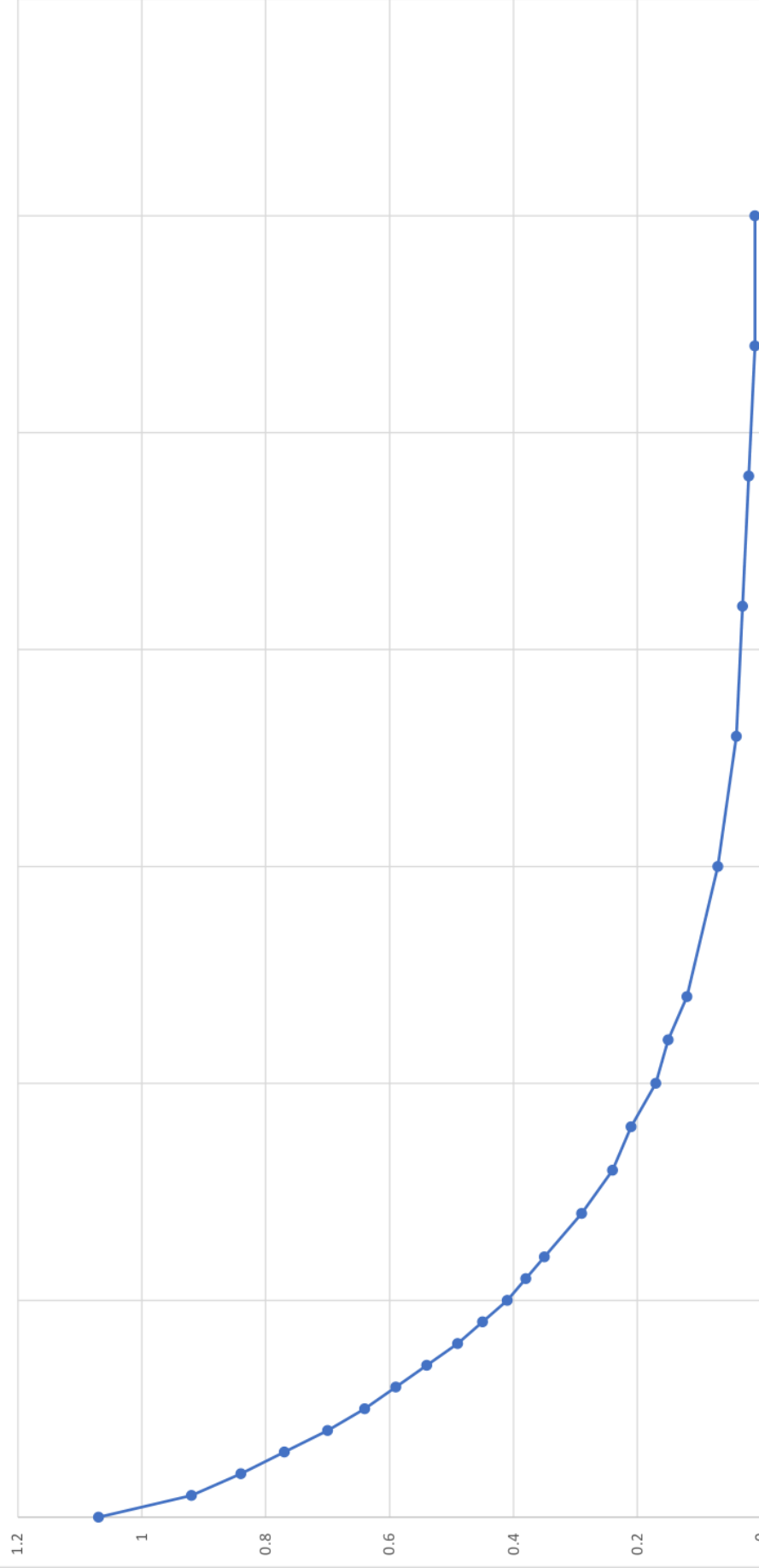


Figure 6

Task 1 and 2 maths

The second method was using various maths equations to prove the current and voltage that would be output at the various time intervals.

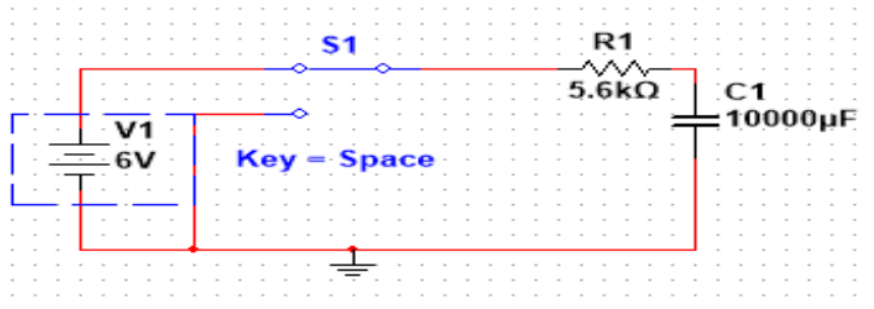


Figure 7

$$\tau = R \times C$$

$$\tau = 5.6 \times 10^3 \times 10 \times 10^{-3}$$

$$\tau = 56 \text{ seconds}$$

Max current

$$I_m = \frac{V}{R}$$

$$I_m = \frac{6}{5.6 \times 10^3}$$

$$I_m = 1.07 \text{ mA (3s.f)}$$

Voltage across the capacitor at different time intervals

$$V_c = V \times \left(1 - e^{-\frac{t}{\tau}}\right)$$

$$V_c = 6 \times \left(1 - e^{-\frac{t}{56}}\right)$$

Now inputting the values chosen

$$V_c = 6 \times \left(1 - e^{-\frac{10}{56}}\right)$$

$$V_c = 0.981 \text{ V (3s.f)}$$

$$V_c = 6 \times \left(1 - e^{-\frac{60}{56}}\right)$$

$$V_c = 3.94 \text{ V (3s.f)}$$

$$V_c = 6 \times \left(1 - e^{-\frac{100}{56}}\right)$$

For discharge of a circuit the equation changes slightly to find out the discharge voltage at different times.

$$V_c = V \times \left(e^{-\frac{t}{\tau}}\right)$$

$$V_c = 6 \times \left(e^{-\frac{t}{56}}\right)$$

Now inputting the values chosen

$$V_c = 6 \times \left(e^{-\frac{10}{56}}\right)$$

$$V_c = 5.02 \text{ V (3s.f)}$$

$$V_c = 6 \times \left(e^{-\frac{60}{56}}\right)$$

$$V_c = 2.06 \text{ V (3s.f)}$$

$$V_c = 6 \times \left(e^{-\frac{100}{56}}\right)$$

$$V_c = 1.00 \text{ V}$$

$$1.00 \text{ (3s.f)}$$

$$V_c = 4.99V \text{ (3s.f)}$$

Now the same can be done for current using this simple equation. But where current differs from voltage when working both out is that it's the exact same equation for charge and discharge but the value received is a negative and so just put a minus before it when recording.

current across the capacitor at different time intervals

$$I_c = I_m \left(e^{-\frac{t}{\tau}} \right)$$

$$I_c = 1.07 \left(e^{-\frac{t}{56}} \right)$$

Now inputting the values chosen

$$I_c = 1.07 \left(e^{-\frac{10}{56}} \right)$$

$$I_c = 0.836mA \text{ (3s.f)}$$

$$I_c = 1.07 \left(e^{-\frac{60}{56}} \right)$$

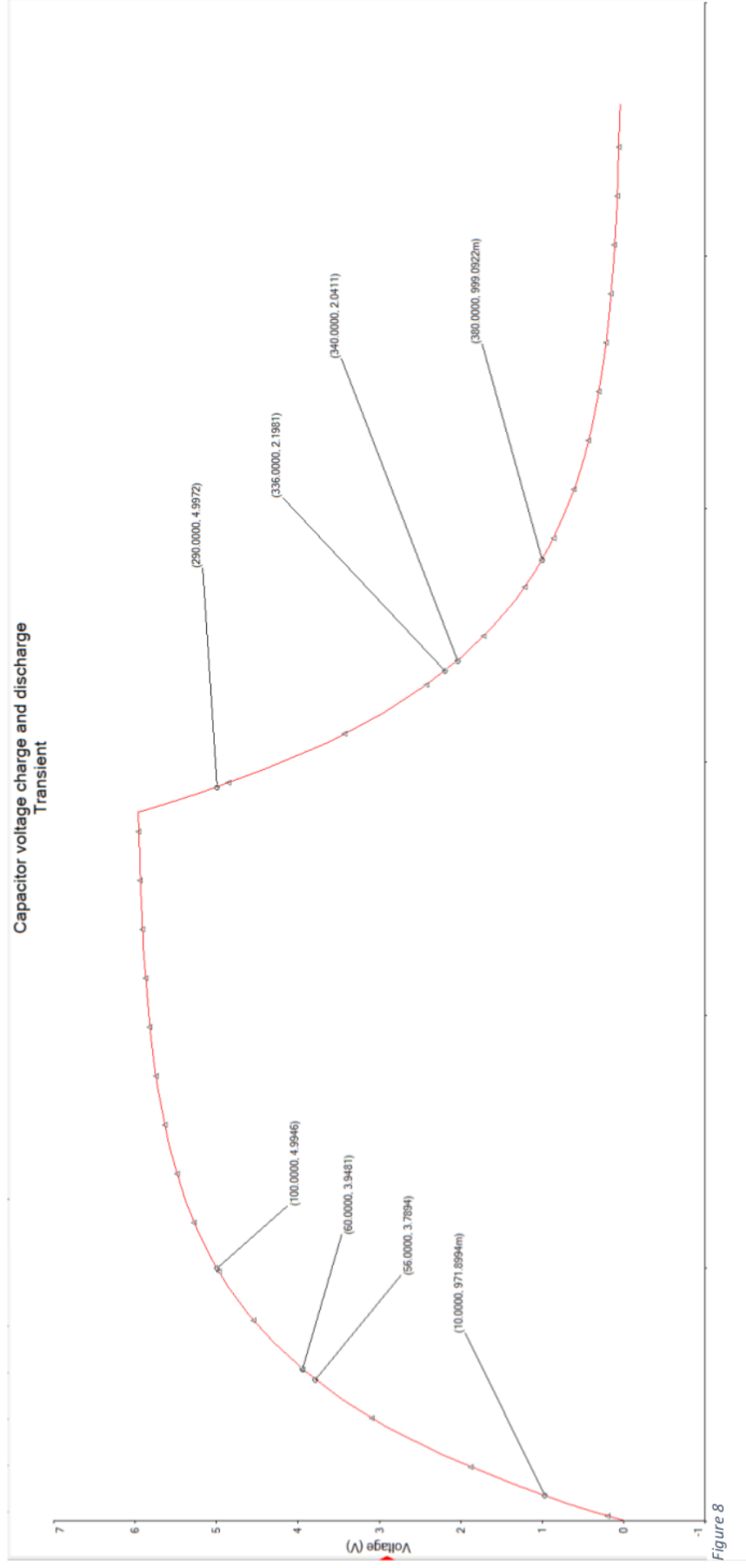
$$I_c = 0.342mA \text{ (3s.f)}$$

$$I_c = 1.07 \left(e^{-\frac{100}{56}} \right)$$

$$I_c = 0.167mA \text{ (3s.f)}$$

Task 1 and 2 Multisim

The third method of proving this was to draw the circuit on a computerised program called NI Multisim V14.1. after the circuit was drawn there is measuring devise that can be added to monitor certain things. The NI Multisim program was set to Transient sweep with a start time of 0 seconds and a stop time of 560 seconds. This was so the full charge and discharge could be monitored at once.



Capacitor current charge and discharge
Transient

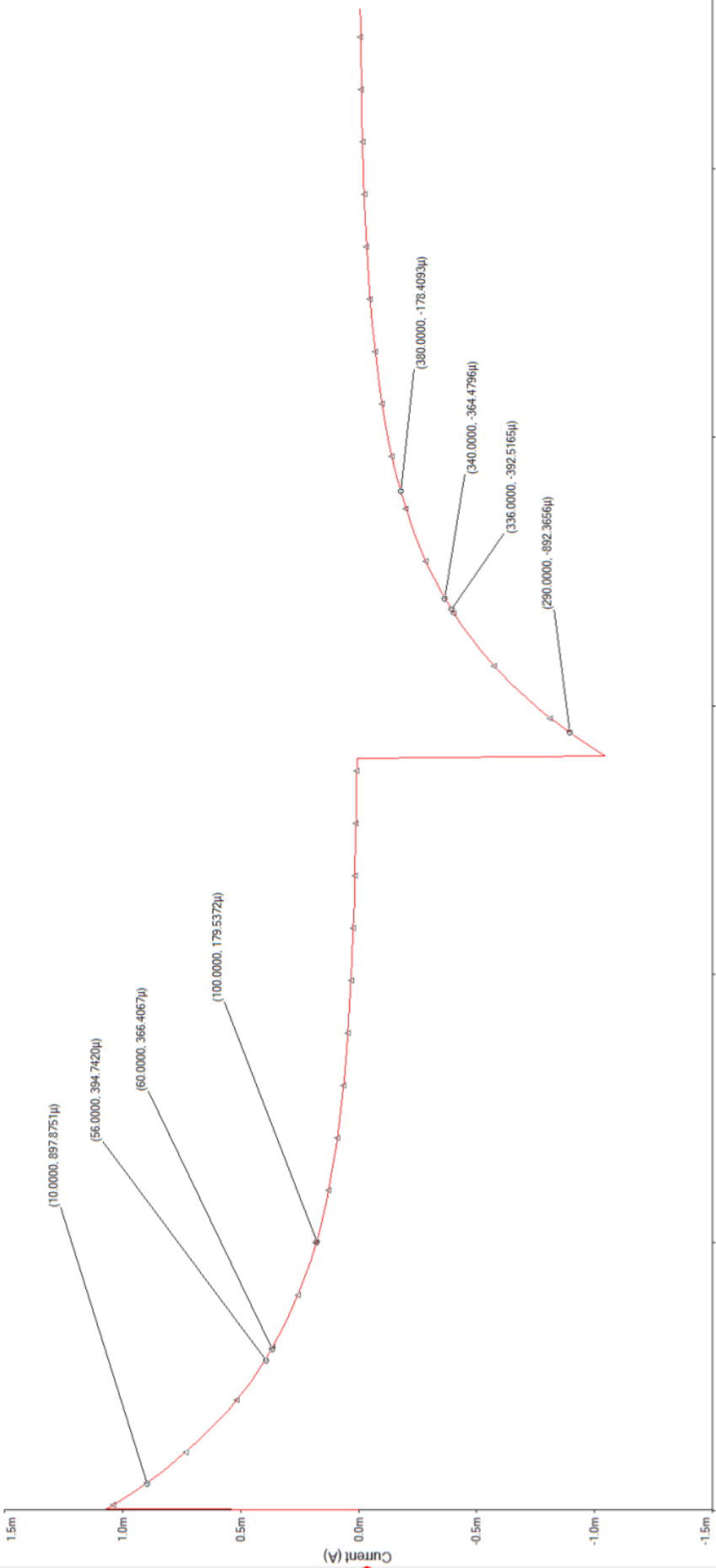


Figure 9

Task 3

Task 3 is an R-C like in tas 1 but it has one resistor in series and one in parallell, the circuit looks like this:

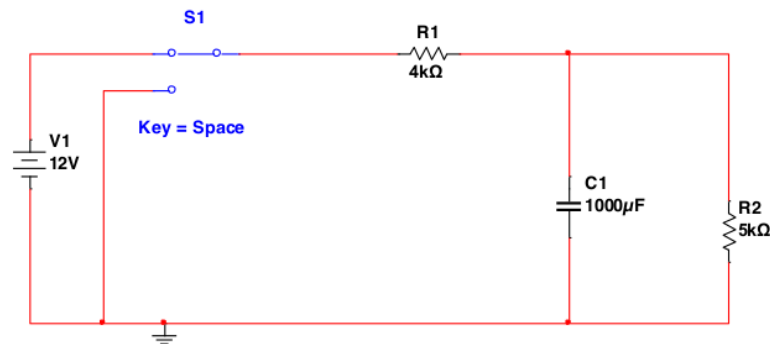


Figure 10

For this task there was no practical carried out and so the results compared are through maths equations and Multisim.

Now to make this into one circuit you must use the equation product over sum to get the resistors into one and then the voltage will also chance. The equations look like this :

$$R_t = \frac{R1 * R2}{R1 + R2} = \Omega \quad R_t = \frac{4 * 5}{4 + 5} = 2.2k\Omega$$

$$V = \frac{R2}{R1 + R2} * V = V \quad V = \frac{5}{4 + 5} * 12 = 6.6V$$

$$I_m = \frac{V}{R_t} = A \quad I_m = \frac{6.6}{2.2k} = 3mA$$

The new reduced circuit will look like this :

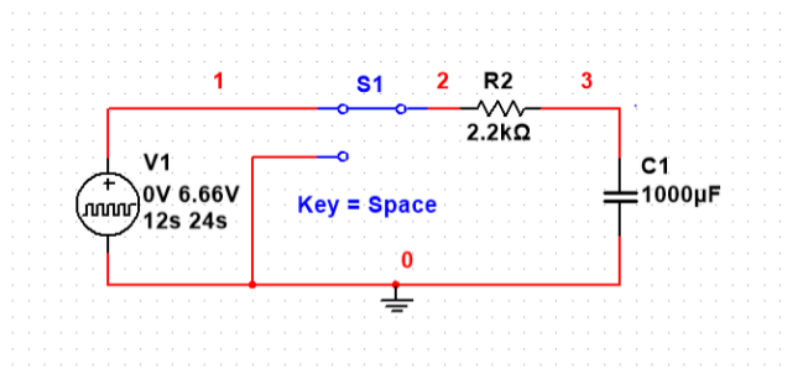


Figure 11

Task 3 Multisim

Markers have been put at intervals of 3 seconds. This is so when the mathematical equations are used the 3 second intervals can be used within the equation and also will be used to compare the Multisim and maths at the same points in time. From the markers I can conclude it took 12 seconds to fully charge and a further 12 seconds to fully discharge and so I estimate the time constant to be the 12 seconds it took to fully charge divide by the 5 time constants it takes for a capacitor to charge which comes out as 2.4 seconds for 1 time constant.

Task 3 Current across capacitor

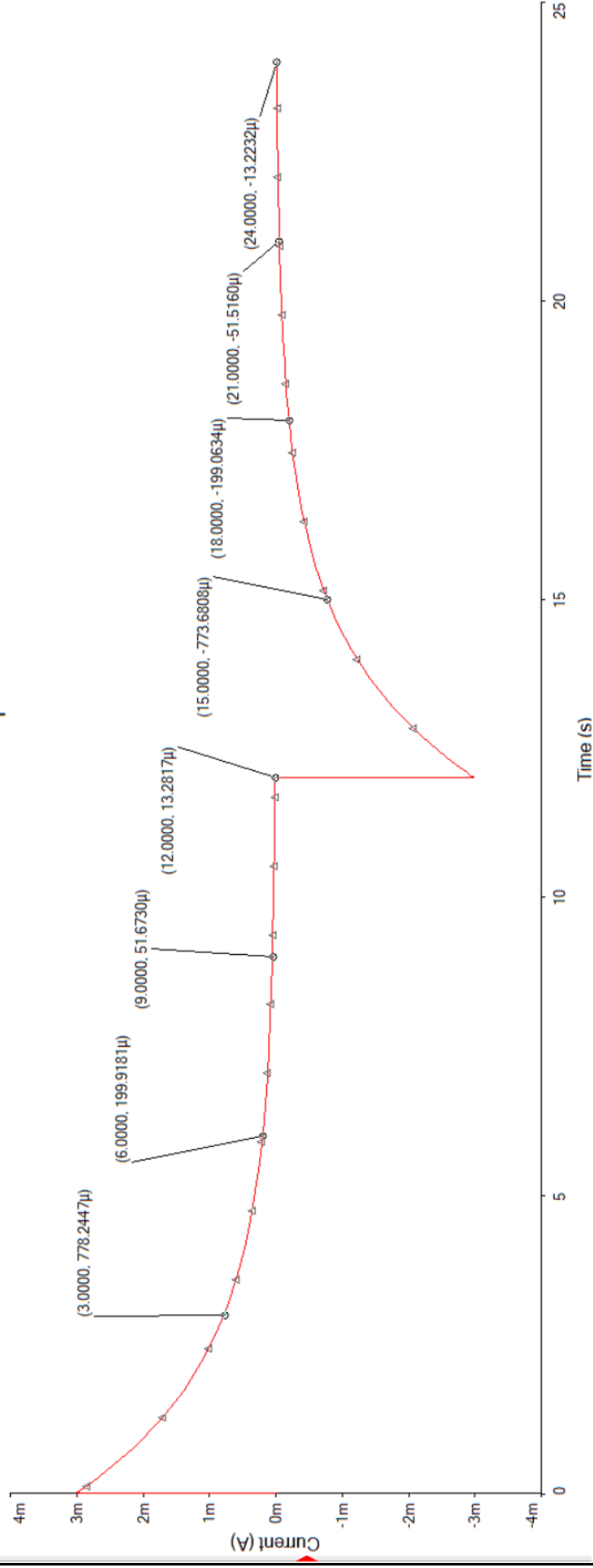


Figure 12

Task 3 Maths

Now to find the real time constant you use the equation $R \times C$ which comes out as this:

$$R * C = \tau$$

$$\tau = 2.2 \times 10^3 \times 1000 \times 10^{-6}$$

Now this can be used within the exponential equation using the same time intervals as on Multisim :

Charge

$$I_{c1} = 3mA \left(e^{-\frac{-3}{2.2}} \right)$$

$$I_{c1} = 767\mu A \text{ (3s.f)}$$

$$I_{c2} = 3mA \left(e^{-\frac{6}{2.2}} \right)$$

$$I_{c2} = 196\mu A \text{ (3s.f)}$$

$$I_{c3} = 3mA \left(e^{-\frac{9}{2.2}} \right)$$

$$I_{c3} = 50.2\mu A \text{ (3s.f)}$$

$$I_{c4} = 3mA \left(e^{-\frac{12}{2.2}} \right)$$

$$I_{c4} = 12.8\mu A \text{ (3s.f)}$$

And for discharge current of a capacitor it's the exact same just negative as its discharging.

As seen from the Multisim circuit the current starts on 3mA decays down to 0mA when charging the capacitor. When discharging the capacitor the opposite happens and it starts on -3mA and rises to 0mA at the end. The equations can also be used to back this:

$$I_c = 3mA \left(e^{-\frac{0}{2.2}} \right)$$

$$I_c = 3\mu A \text{ (3s.f)}$$

$$I_c = 3mA \left(e^{-\frac{11}{2.2}} \right)$$

$$I_c = 20.2\mu A \text{ (3s.f)}$$

For 11 seconds which would be 5 official time constants it should be equal to 0mA as seen on the Multisim but using the equation shows us it not.

Task 4

Task 4 uses an inductor instead of a capacitor and so the equations are different to work out any information a practical would've been carried out but a 3H inductor is near impossible to obtain and so this task is carried out using Multisim and the maths equations again to compare between the two. This is what the Multisim looks like:

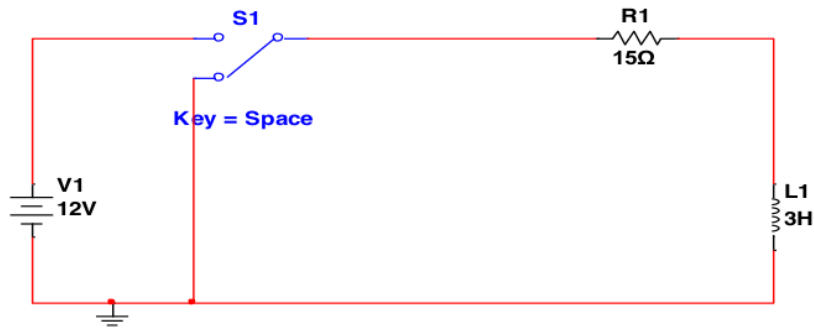


Figure 13

Task 4 Maths

To work out the time constant for an inductor the equation $\tau = \frac{L}{R}$ is used. With the present values it looks like this $\tau = \frac{3}{15}$ and the result came out as $\tau = 0.2s$. From this the exponential equation can be used to find the current at different time intervals and compare them to the same time intervals on Multisim. Firstly the I_{max} is needed and this is done by using ohms law:

$$I = \frac{V}{R}$$

$$I = \frac{12}{15}$$

$$I = 0.8A$$

And then implementing it back into the Exponential equation as shown here:

$$I_{c1} = 0.8A \left(1 - e^{-\frac{0.2}{0.2}} \right)$$

$$I_{c1} = 505mA \ (3s.f)$$

$$I_{c2} = 0.8A \left(1 - e^{-\frac{0.4}{0.2}} \right)$$

$$I_{c2} = 691mA \ (3s.f)$$

$$I_{c3} = 0.8A \left(1 - e^{-\frac{6}{0.2}} \right)$$

$$I_{c3} = 760mA \ (3s.f)$$

$$I_{c4} = 3mA \left(1 - e^{-\frac{8}{0.2}} \right)$$

$$I_{c4} = 785mA \ (3s.f)$$

$$I_{c4} = 0.8A \left(1 - e^{-\frac{10}{0.2}} \right)$$

$$I_{c4} = 800mA \ (3s.f)$$

Task 4 Multisim

This is the Multisim of the inductor current with markers placed on the same time intervals as used for the maths equations above

Task 4 Inductor Current

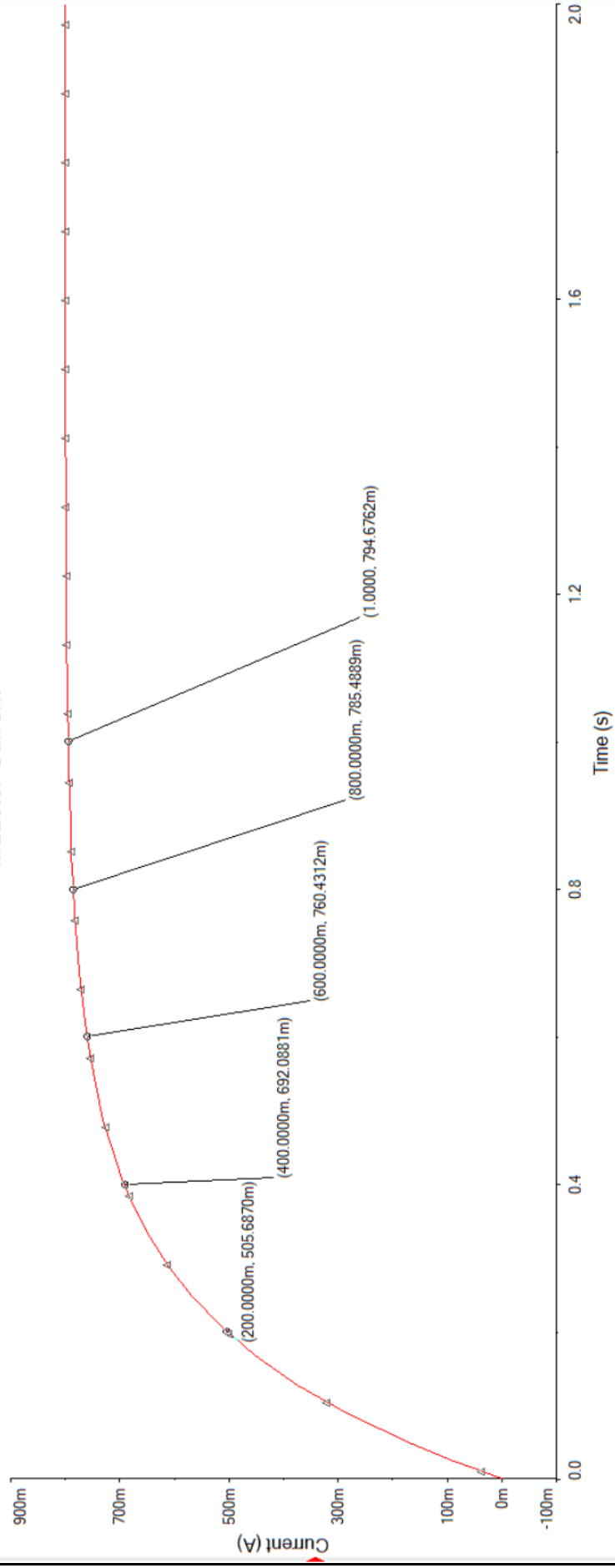


Figure 14

Now to prove the values that would've been received at 100mA and 10mA the original equation which looked like this $I = I_{max}(e^{-\frac{t}{\tau}})$ and alter it so that you make t the subject:

$$I = I_{max}(e^{-\frac{t}{\tau}})$$

$$\ln\left(\frac{I}{I_{max}}\right) = -\frac{t}{\tau}$$

$$-t = \tau[\ln\left(\frac{I}{I_{max}}\right)]$$

Now the adapted formulae can be used to determine the times in which the specific currents were achieved

$$t = \tau[\ln\left(\frac{I}{I_{max}}\right)]$$

$$t = 0.2[\ln\left(\frac{100 \times 10^{-3}}{0.8}\right)]$$

$$\tau = 0.416$$

$$t = \tau[\ln\left(\frac{I}{I_{max}}\right)]$$

$$t = 0.2[\ln\left(\frac{10 \times 10^{-3}}{0.8}\right)]$$

$$\tau = 0.876$$

Background Knowledge

Tau

Time constant is the delay time it takes for the reactive components within a circuit to react when connected to a source or signal. The reactive parts are inductive or capacitive so either an inductor or capacitor. As they take time to fully react when powered the delay time can be worked out and is then named tau or the symbol τ . For example tau of a capacitor can be worked out using the equation $R \times C$ or using percentages of 36.5% or 63.5% depending on if its charging or discharging. It is known to take 5 time constants to full charge or discharge a capacitor. (Tutorials, n.d.)

Conclusion

Task 1 and 2 conclusion

With regards to task 1 and 2 the results between all three methods had slight differences. For the practical test this can be down to multiple things, firstly would be the components not being the exact figures as on the circuit. It's very hard to get an extremely accurate resistor. It is the same concept with the capacitor as it probably wasn't exactly 10,000uF and so these slight differences can cause problems to the results that were obtained. The second reason would be because the power supply used was not very accurate as perfectly accurate power supplies are very expensive to purchase and have to be calibrated regularly. the final reason there could be a difference is because when using equations and Multisim its being done on a perfect circuit with no resistance in the cables and as mentioned before the components are not exact. All these factors contribute to the final results and so show why the equations and Multisim can differ from the real practical.

Task 1 and 2 results

Time (s)	Practical (v)	Multisim (v)	Equations (v)
10	1.04	0.971	0.981
60	4.00	3.94	3.94
100	5.05	4.99	4.99
290	5.07	4.99	5.02
340	2.1	2.04	2.06
380	1.05	0.99	1.00

Task 3 conclusion

Task 3 only used the exponential equations and the Multisim circuit, there was no practical to compare it to and so this is one less step in proving accuracy. However the results were extremely close with differences as low as 0.4uA between the two and so this is negligible and so proves that both methods work affectively, using the maths or Multisim. Having a practical would've been an advantage as it could've shown any problems such as cable resistance, power supplies or any other inaccuracies within the circuit and furthermore the affects they would have on the results received from the other two perfect methods. This would've made for a more accurate report and better comparison between the three methods. For this task an initial estimate on the time constant was made and came out as 2.4 seconds as it first appeared that it took 12 seconds for the capacitor to fully charge and then discharge and this was concluded from Multisim. Knowing that it takes 5 time constants to full charge a capacitor the 12 seconds recorded divided by the 5 time constants it takes comes out at 2.4 seconds. When using the maths equations it was found that the real time constant was 2.2 seconds and so $5 \times 2.2 = 11$ seconds. This was down to human error when inputting the times within Multisim.

Task 3 results

Time (s)	Multisim	Equation
3	778uA	767uA
6	199uA	196uA
9	51.7uA	50.2uA
12	13.3uA	12.8uA
15	-773uA	-767uA
18	-199uA	-196uA
21	-51.5uA	-50.2uA
24	-13.2uA	-12.8uA

Task 4

For task 4 it was an inductor and resistor instead of the capacitor resistor circuit that was found within tasks 1,2 and 3. This meant there was different equations needed and is a completely different circuit all together. There was no practical carried out with task 4 which means the report and comparison is less accurate as there is only two methods to compare unlike the three used in tasks 1 and 2. This is down to a 3henry inductor being used within the circuit which an extreme value as inductors are most commonly extremely small values down to micro and even nano Henries. three ways of comparison is more accurate but the as two ways of comparison is still acceptable for a valid comparison and conclusion.

Time	Multisim	Maths
0.2	505mA	505mA
0.4	692mA	691mA
0.6	760mA	760mA
0.8	758mA	785mA
1	794mA	800mA

Figure 1	3
Figure 2	4
Figure 3	5
Figure 4	5
Figure 5	6
Figure 6	7
Figure 7	8
Figure 8	10
Figure 9	11
Figure 10	12
Figure 11	12
Figure 12	13
Figure 13	15
Figure 14	16

FINAL GRADE

GENERAL COMMENTS

Instructor

66/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

GRADING FORM: NEW CSG-RUBRIC

JASON SANGER**66****1. ENGAGEMENT WITH LITERATURE**

NA

2. KNOWLEDGE AND UNDERSTANDING

2. Good level of knowledge, accurate results, few minor errors and omissions as marked 18/25

18**3. COGNITIVE AND INTELLECTUAL**

3. Sound evaluation. Test results are tabulated and proof of results given in graphical analysis, consider using theory up front to aid with explaining equations e.g. 63.2% 20/30

20**4. PRACTICAL APPLICATION**

4. Very good application of basic methods, although



not always explained in detail 14/25

14

5. TRANSFERABLE SKILLS



5. Work is coherent and mostly well organised,
graphs are good, written communication is adequate.
Conclusion is good. 14/20

14