

PSDE4001 Assignment 1

by Callum Williams

FILE	15328_CALLUM_WILLIAMS_PSDE4001_ASSIGNMENT_1_139105_9083964 41.DOCX (2.01M)		
TIME SUBMITTED	21-JAN-2018 10:51PM (UTC+0000)	WORD COUNT	1728
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HNC ELECTRICAL &

ELECTRONIC

ENGINEERING

PSDE4001

ASSIGNMENT 1 –

Investigation into DC

Transients

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Date: 04/12/17

Word Count: 1864

Contents

1. Introduction	3
2. Circuit testing	4
3. Testing Results and Discussion	14
4. Conclusions and Recommendations	15
5. Appendix	16

1. Introduction

This Assignment is setting out to analysis the behaviour of RC and RL circuits when connected to a DC power source, this will be done on a simulation programme and also a real time test will be carried out on the charging and discharge of a capacitor over a certain time period.

In this assignment I hope to apply correct mathematical formulae and present the correct DC transient graphs to show the trends in both the RL and RC circuits.

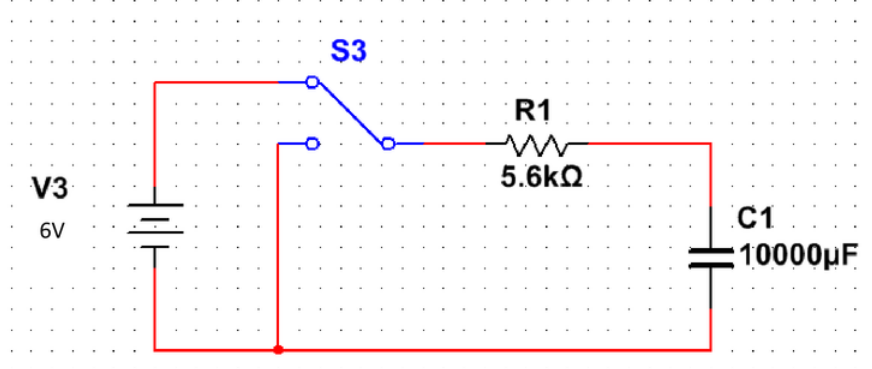
I will be studying the voltage change in the capacitor when charging and discharging, this data will then be transformed into a table and then eventually into a graph after doing this I will compare theoretical values with the simulated values. I will then redo this step for the current using specific sums we have learnt up until these tests.

2. Circuit testing

Task 1 - Transient Behaviour for the Charging of a Capacitor

In this Task I aim to carry out the testing of this particular circuit in a real-life demonstration, these values were chosen as the capacitor would charge and discharge in a small-time frame where it would be ideal to take measurements during both the charging and discharging phases. We choose an appropriate time constant as we were limited on a time so we needed to be able to take measurements frequently but not over a drastically long-time scale.

I choose these components for the circuit as the sum gave it an overall time of 280 second for its



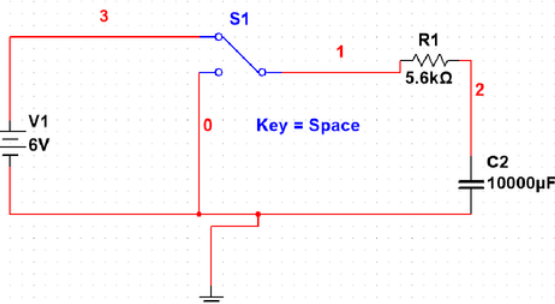
transient period which was an ideal time to take measurements as well as carrying out the tests swiftly the first sums I did was to work out the time constant.

$$t = R \times C$$

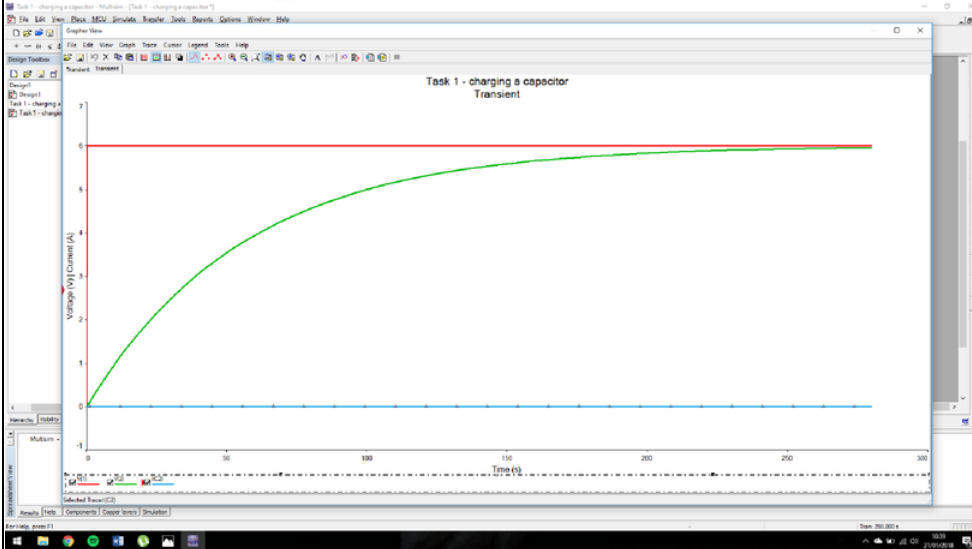
So, using my capacitance and resistor I worked out the value

$T = 5600 \times (10000 \times 10^{-6})$ this gave me a result of 56 using this result I could then work out the transient period which was simply worked out using the equation $5 \times t$. applied to my circuit the sum would read $5 \times 56 = 280$.

After working out the transient time it was possible to carry out a certain sum to give you a rough estimate of voltage in a charging/discharging capacitor at any give instance over its 280 second transient period.

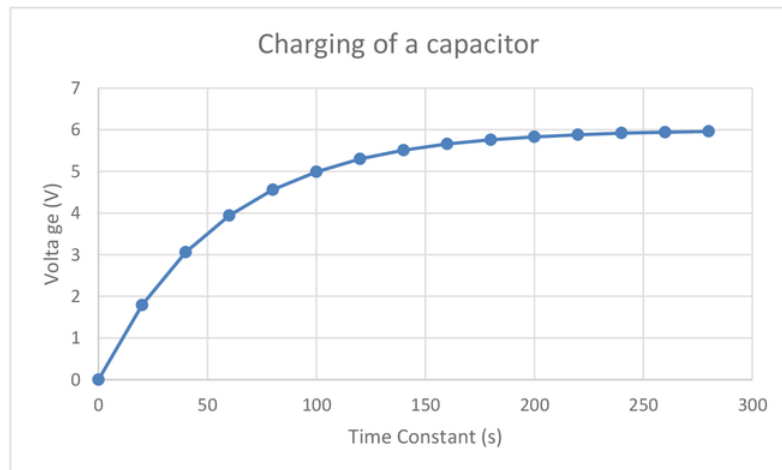


the first step of the task was to build this circuit on multisim, once this circuit was built the charging measurements were took at every 20 second interval. Here below is my charging capacitor graph.



Time Constant (t)	Voltage (v)
20	1.79
40	3.06
60	3.94
80	4.56
100	4.99
120	5.30
140	5.51
160	5.66
180	5.76
200	5.83
220	5.88
240	5.92
260	5.94
280	5.96

Here is a table and graph of the voltage during the charging process of the capacitor.



Prior to carrying out this task I came up with some theoretical values of what the capacitors voltage should be when given any random time constant. In this instant I used 50, 100 and 150 seconds as my testing times.

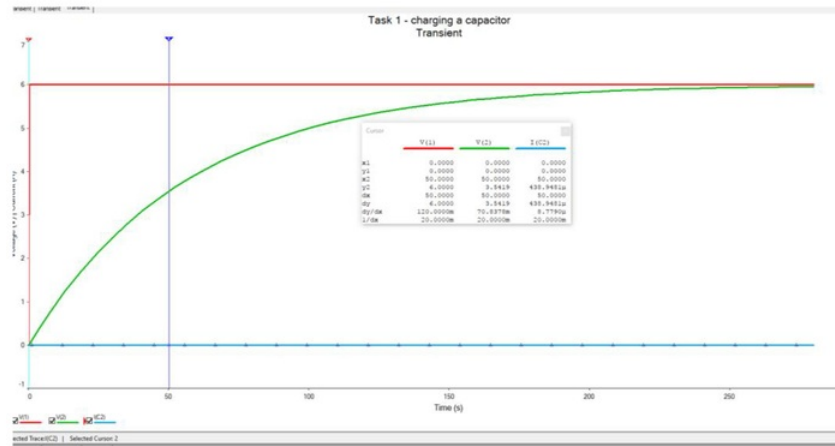
To work out these values I would have to use the sum $VC = Vs (1 - e^{-t/T})$ to apply this sum to my circuit was a simple process and these where the following answers

Voltage at 50 seconds

$VC = Vs (1 - e^{-t/T})$

so

$VC = 6v (1 - e^{-50/56}) = 3.54 \text{ V}$



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	V(1)	V(2)	I(C2)
x1	0.0000	0.0000	0.0000
y1	0.0000	0.0000	0.0000
x2	50.0000	50.0000	50.0000
y2	6.0000	3.5419	438.9481μ
dx	50.0000	50.0000	50.0000
dy	6.0000	3.5419	438.9481μ
dy/dx	120.0000m	70.8378m	8.7790μ
1/dx	20.0000m	20.0000m	20.0000m

Pictured to the left is the proof of my simulation against what I had calculated to be the voltage at 50 seconds

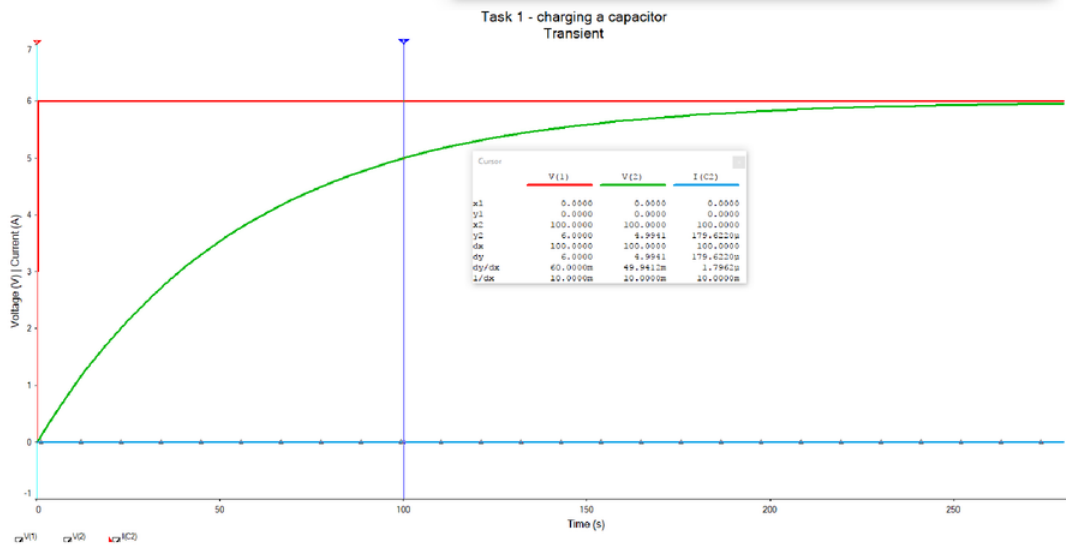
Voltage at 100 seconds

$$VC = V_s (1 - e^{-t/T})$$

so

$$VC = 6v (1 - e^{-100/56}) = 4.99 \text{ V}$$

Here below and beside is proof of my calculations in comparison to my simulation.



Voltage at 150 seconds

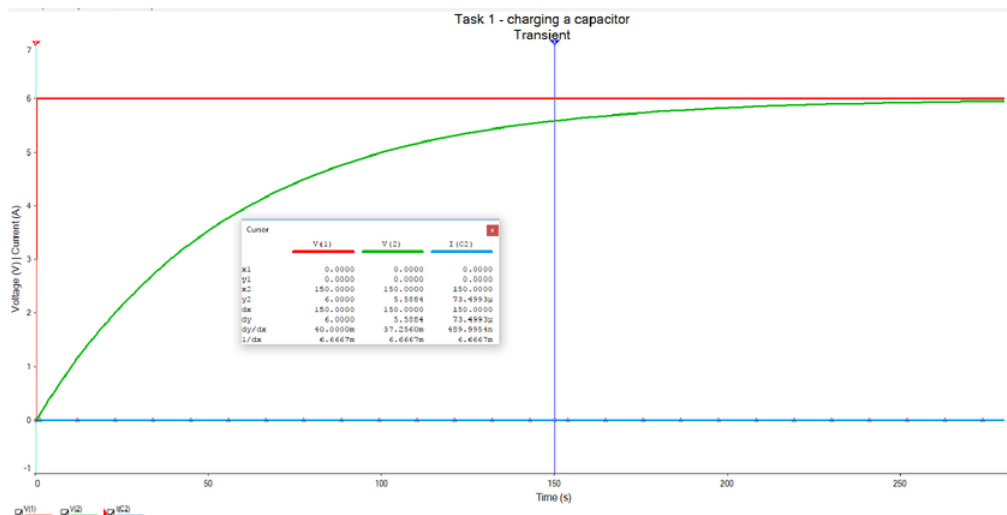
$$VC = V_s (1 - e^{-t/T})$$

so

$$VC = 6v (1 - e^{-150/56}) = 5.59 \text{ V}$$

Here beside and at the top of the next page is proof of my simulation and sum recorded at the time of 150 seconds.

Cursor			
	V(1)	V(2)	I(C2)
x1	0.0000	0.0000	0.0000
y1	0.0000	0.0000	0.0000
x2	150.0000	150.0000	150.0000
y2	6.0000	5.5884	73.4993μ
dx	150.0000	150.0000	150.0000
dy	6.0000	5.5884	73.4993μ
dy/dx	40.0000m	37.2560m	489.9954n
1/dx	6.6667m	6.6667m	6.6667m



After testing the voltage, it was time to test the current however due to errors on multisim my current wasn't behaving as it should but I was still able to calculate the theoretical values using the sum -

$$I_C = I_{max}(e^{-t/T})$$

however, I do not have the value of I_{max} so to work this out the sum is -

$$I_{max} = V_s/R$$

In my circuit it would read

$$I_{max} = 6/5.2k \text{ so } I_{max} = 1.15 \text{ mA}$$

So to work out the current at any time I could apply the I_{max} I have just figured out to the sum

$$I_C = I_{max}(e^{-t/T})$$

IC at 50 seconds

$$I_C = I_{max}(e^{-t/T})$$

so

$$I_C = 1.15 (e^{-50/56})$$

$$I_C = 0.47\text{mA}$$

IC at 100 seconds

$$I_C = I_{max}(e^{-t/T})$$

so

$$I_C = 1.15 (e^{-100/56})$$

$$I_C = 0.19\text{mA}$$

IC at 150 seconds

$$I_C = I_{max}(e^{-t/T})$$

so

$$I_C = 1.15 (e^{-150/56})$$

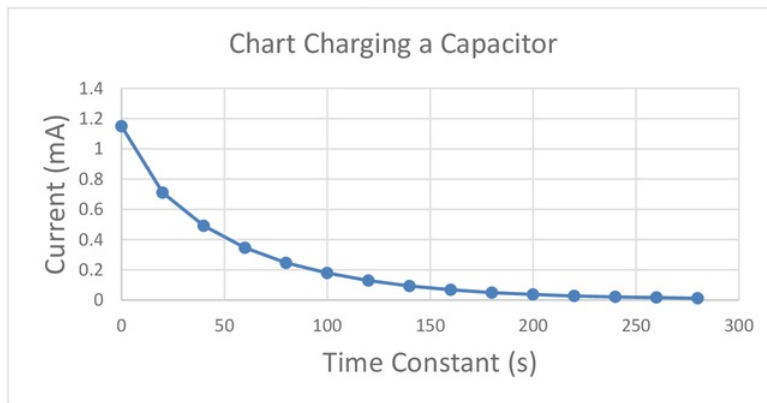
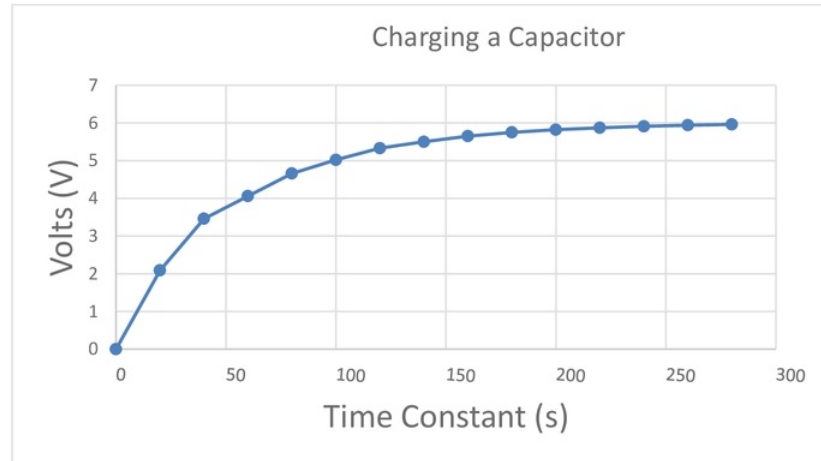
$$I_C = 0.08\text{mA}$$

During this testing I found that my theoretical values matched up with my actual values from the simulation.

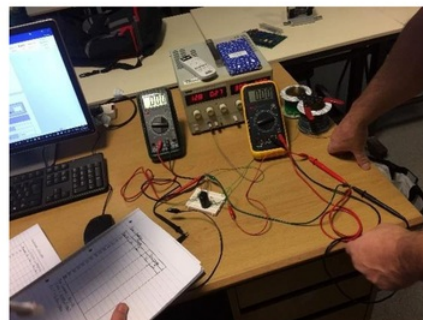
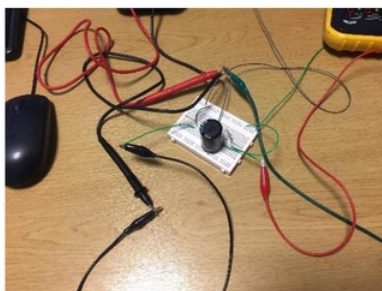
The values only varied differently but this was due to the components in the circuit however this was expected before carrying out the required tests.

Time	Vc	Ic
0	0	0
20	2.09	0.71
40	3.46	0.491
60	4.06	0.346
80	4.66	0.246
100	5.02	0.179
120	5.33	0.129
140	5.5	0.093
160	5.65	0.068
180	5.75	0.049
200	5.82	0.037
220	5.87	0.027
240	5.91	0.021
260	5.94	0.017
280	5.96	0.012

This is my real-life testing table for the charging of the capacitor it is similar to the multisim simulation one and the graph has the same sort of shape however there are large differences in the values but this is most defiantly due to the tolerances on the components we used in real life as they are not as accurate as the ones used in simulation.



Here is proof of our testing using equipment in class to time and measure readings from the capacitor whilst it charges.



Task 2 - Transient Behaviour for the Discharging of a Capacitor

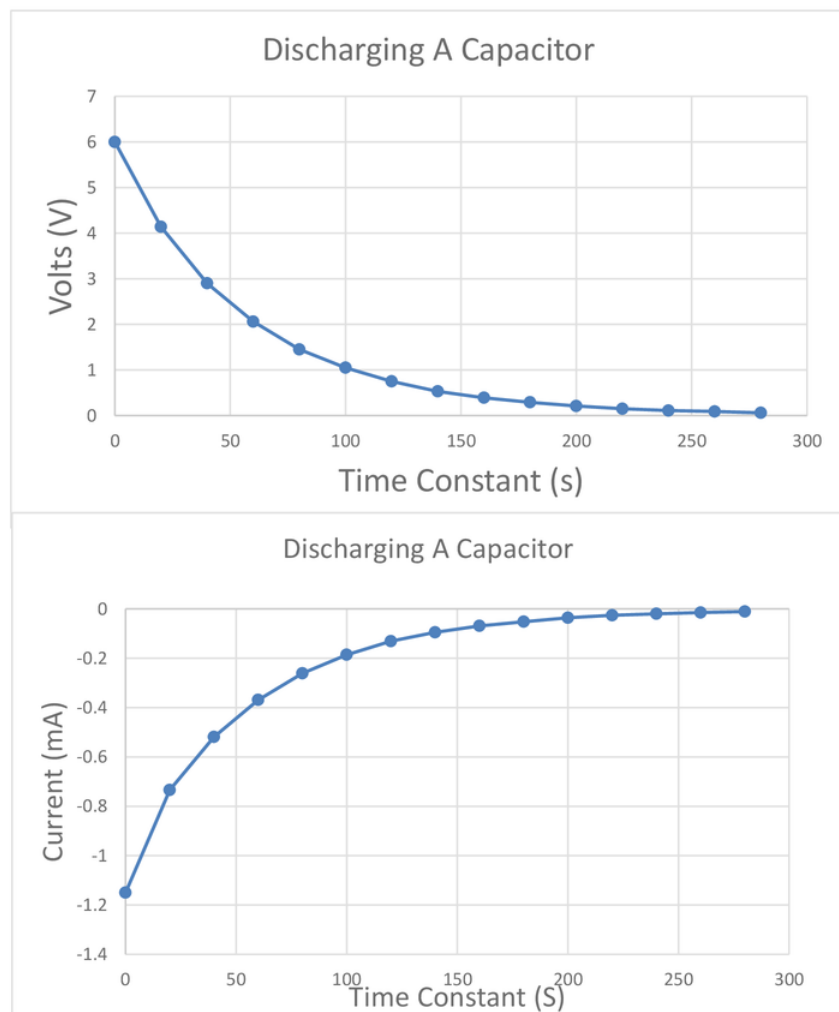
For this task I have been instructed to analysis the voltage and current during the charging and discharging phase of the capacitor, this would be done over a 280 second period with the same circuit used in task 1, I will be using a theoretical value and a simulated value to compare the differences between the two however during the testing I will be taking in to consideration the tolerances of the components and how the results could differ between the two.

When carrying out the discharge test in real life me and my colleagues all had an allocated role, myself in this instance had the role of measuring the voltage over the duration of the discharge transient test.

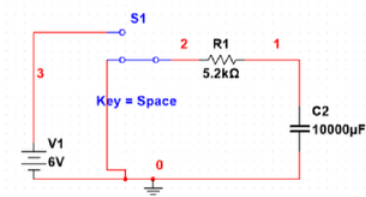
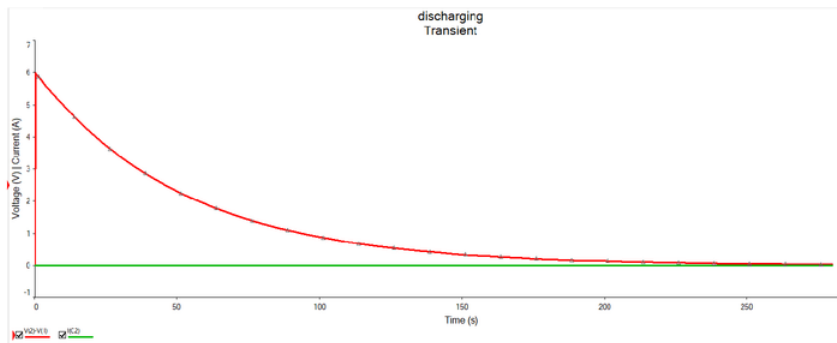
With the readings from my colleagues and from my own findings I managed to put together this Table & Graph

Time	Vc	Ic
0	6	-1.15
20	4.14	-0.734
40	2.9	-0.519
60	2.06	-0.369
80	1.45	-0.261
100	1.05	-0.186
120	0.75	-0.131
140	0.53	-0.095
160	0.39	-0.069
180	0.29	-0.052
200	0.21	-0.036
220	0.15	-0.026
240	0.11	-0.020
260	0.09	-0.015
280	0.06	-0.011

Here are my graphs to show the trend in the discharging of the capacitor, one graph for the current and one for the voltage.



Here are some pictures of my simulated discharging circuits graph and components



The simulated graphs shared a similarity with my actual practical test however some values were different but this was only due to tolerances on the components used, this difference stands out because all simulated variants of components are set to their most desired/optimal value as in real life its hard to get that type of accuracy.

Simulated measurements at 3 given points compared to theoretical measurements.

The sum for working out discharge is as follows $V_c = V_s \times e^{-t/T}$ so to work out the value at any of the following times this would be the sum used

50 seconds

$$V_c = V_s \times e^{-t/T}$$

So

$$V_c = 6 \times e^{-50/56}$$

$$V_c = 2.46V$$

150 seconds

$$V_c = V_s \times e^{-t/T}$$

So

$$V_c = 6 \times e^{-150/56}$$

$$V_c = 0.41V$$

100 seconds

$$V_c = V_s \times e^{-t/T}$$

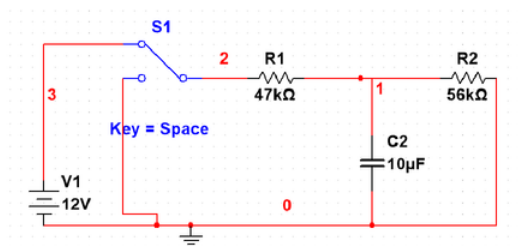
So

$$V_c = 6 \times e^{-100/56}$$

$$V_c = 1.01V$$

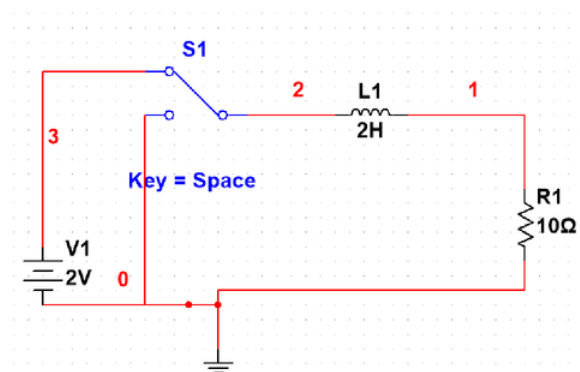
In comparison to my Theoretical values the simulated values matched up perfectly however the actual practical discharge test values were similar but not completely identical but as mentioned before this is just due to tolerance issues with the components.

Task 3



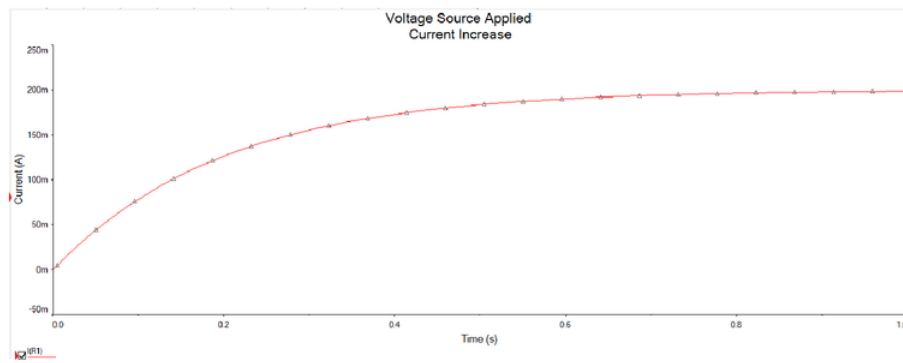
The sum for resistors in parallel is $R1 \times R2 / R1 + R2$ I applied this sum to the circuit so I could get a resistance total (RT) in this instance the sum gave me the result of 25.6k.

Task 4



for this circuit I had to work out the time constant before I could get up any graphs or carry out any sums, to do this I used the sum $L/R = t$ in this instance the sum would be $2/10 = 0.2s$ so to work out the transient time I used the sum $t \times 5 = T$ in this instance the sum was $0.2 \times 5 = 1$ second.

Now with this figured out I could work out the current growth when the voltage source is applied to the circuit.



Now using the Sum $I = V/R (1 - e^{-Rt/L})$ I will work out the current at multiple random points and compare my theoretical value with my simulated one.

0.2 seconds

$$I = V/R (1 - e^{-Rt/L})$$

So

$$I = 2/10 (1 - e^{-10 \times 0.2/2}) = 0.126 \text{ A or } 126\text{mA}$$

0.4 seconds

$$I = V/R (1 - e^{-Rt/L})$$

So

$$I = 2/10 (1 - e^{-10 \times 0.4/2}) = 0.173 \text{ A or } 172\text{mA}$$

0.6 seconds

$$I = V/R (1 - e^{-Rt/L})$$

So

$$I = 2/10 (1 - e^{-10 \times 0.6/2}) = 0.190 \text{ A or } 190\text{mA}$$

When I compared the results from my theoretical sums to what I had on the simulation it matched and I had done the calculations correctly.

3. Testing Results and Disscusion

4. Conclusions and Recommendations

Task 1 & 2 went okay and I was able to plot the required graphs and carry out the test with my group however when getting on to multisim my current wasn't going up/down with the charge or discharging transient periods, this cause an issue because I did not have a simulated value to compare to my actual value and theoretical value I worked out from the sum.

Task 3 & 4 I struggled with, although I made notes I didn't Cleary understand what to do to on multisim to get the data that I required, this unfortunately resulted in me being unable to answer the tasks.

If I was to carry out this assignment again I would probably try and gain a better understanding on multisim so I could identify my errors when I got stuck I would also try and do more research into DC transient than I did before and wold try and allocate more of my time to finishing the assignment.

5. Appendix

PSDE4001 Assignment 1

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

40/100

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

GRADING FORM: CSG-RUBIC

CALLUM WILLIAMS

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RESEARCH-INFORMED LITERATURE

KNOWLEDGE AND UNDERSTANDING

 Weak understanding shown.

10/25

ANALYSIS

 there is an analysis, but there are many parts missing. Minor errors in the tasks.

17/40

PRACTICAL APPLICATION AND DEP.

 Only some tasks have been completed. There are many parts incomplete.

9/25

SKILLS FOR PROFESSIONAL PRAC.

 Lacks clarity.

4/10