

RJ assignment 1 investigation into DC transients

by Mason Morgan

FILE	13695_MASON_MORGAN_RJ_ASSIGNMENT_1_INVESTIGATION_INTRO_DC_TRANSIENTS_139105_697507409.DOCX (2.67M)		
TIME SUBMITTED	28-JAN-2019 02:40PM (UTC+0000)	WORD COUNT	4896
SUBMISSION ID	99925781	CHARACTER COUNT	23177

Name - Mason Morgan

Assignment title: Investigation into DC transients

Contents page

Task 1: Transient Behaviour for the Charging of a Capacitor.	<u>Pages 4-11</u>
• 1.1) Explanation of the circuit	4
• 1.2) Discrepancies during the practical carried out	5
• 1.3) Formula for instantaneous voltage	5
• 1.4) Formula for instantaneous current	5
• 1.5) Transient period	6
• 1.6) Practical results	6
• 1.7) Graphs for charging V_c and I_c curves	7-9
• 1.8) Explanation of graphs indicating any trends	10
• 1.9) RC Charging Table	10
• 1.10) Comparison table (CHARGE).....	11
 Task 2: Transient behaviour for a discharging capacitor	 <u>Pages 12-16</u>
• 2.1) Practical results	12
• 2.2) Graphs for discharging V_c and I_c curves	12
• 2.3) Explanation of graphs	13
• 2.4) Multisim of practical discharge	13-15
• 2.5) Comparison table (DISCHARGE)	15-16
 Task 3: Transient behaviour for a complex circuit.	 <u>Pages 17-26</u>
• 3.1) Task overview	17
• 3.2) Initial and Final condition of capacitor	17
• 3.3) Final result (Step 1)	17
• 3.4) Equivalent circuit (Step 2)	18
• 3.5) Removing power supply (Step 3)	18
• 3.6) Reduction of parallel circuit (Step 4)	18
• 3.7) Calculating the new Voltage supply (Step 5)	19
• 3.8) New equivalent circuit	19
• 3.9) 3 Instantaneous values for voltage at a charging rate	20
• 3.10) Transient graph for voltage at 3 instantaneous times selected (Charge)	20-21
• 3.11) 3 Instantaneous values for current at a charging rate	21-23
• 3.12) Transient graph for current at 3 instantaneous times selected (Charge)	23
• 3.13) 3 Instantaneous values for voltage at a discharging rate	24
• 3.14) Transient graph for voltage at 3 instantaneous times selected (discharge)	23-24
• 3.15) 3 Instantaneous values for current at a discharging rate	24
• 3.16) Transient graph for current at 3 instantaneous times selected (discharge)	25
• 3.17) Table of values for charge and discharge	26

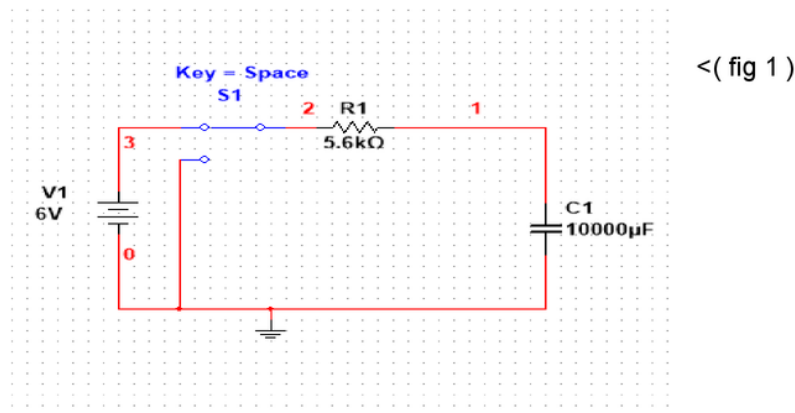
Task 4: Transient behaviour for an inductive circuit.

Pages 26-33

- 4.1) Simulation of the current growth for the first one second after the voltage source is applied to the circuit.....26-27
- 4.2) Carrying out calculations and manually plotting the current 28
- 4.3) Comparing simulation and calculated results 28-32
- 4.4) Current flowing in the circuit immediately before the switch is changed over 32
- 4.5) Comparing the time constant with estimates from manual and simulated plots 32
- 4.6) the time that elapses before the current flowing in the circuit has fallen 33

Table of contents

Task 1: Transient Behaviour for the Charging of a Capacitor



1.1) Explanation of the circuit

The circuit shown above noted fig 1 is a series connected C-R circuit. When S3 is closed you must apply Kirchhoff's voltage law, $V = V_C + V_R$ ($V = 0 + 6$). You can take this from the circuit that V is constant, and that V_C is worked out by the charge acting on the capacitor divided by the capacitor, (q / C). You can then gather that the voltage over the resistor (V_R) is given by IR (Current $\times$ resistance). The initial circuit condition when the circuit is complete, you can assume that the charge on the capacitor is 0, furthermore the capacitor is acting like a switch due to zero current acting upon it, and because of this you can find that V_{C0} is also zero. From the information gathered so far the Voltage formulae noted above is now presented as $V = 0 (V_{C0}) + 6 (V_{R0})$ and therefore V_{R0} is equal to the voltage. As a result at this moment in time at 0 seconds there is no current flowing making the current (I) = 0 which can be derived from the voltage divided by the resistance (V/R).

Later, when time pasted equals 1 second or t_1 seconds with the circuit still being complete the capacitor has been partly charged so you can say q_1 because the current has been flowing for one second. This also affects V_C which is now V_{C1} but is calculated as q_1/C in volts. This then makes the resistor value less because the equation is now $I_1 \times R$ in volts. From this the equation now stands as $V = (q_1/C) + I_1 R$. Once 2 seconds has passed the charge will increase to q_2 making V_C also increase using the charge on the capacitor after two seconds divided by the capacitor in volts (q_2/C). So far you can now say that, because voltage is equal to the voltage over the capacitor add the voltage over the resistor you can gather that the charge over the capacitor is increasing as the time increases however the voltage over the resistor decreases in value as time goes on. Later at the steady state which is equivalent to 5 time constants ($5 \times 1T$) which is worked out by $C \times R$ seconds ($5.6 \times 10^3 \times 10000 \times 10^{-6} = 56 \text{ seconds} = 1\tau$), the capacitor is now fully charged and can be noted as Q coulombs, because of this there is no more flow of current ($I=0$) also meaning that $V_R = IR = 0$. Once the steady state has been reached, you now know that the capacitor has charged completely. When working out the time constant you get a result of 56 seconds for one time constant, because of this you use the equation ($5 \times 56 = 280 \text{ seconds}$) which gives you the amount of time for the capacitor to charge. Furthermore for the practical highlighted below we now know our time boundary needed for the charge of the capacitor, however when also recording discharge you'll have to multiply the charge in seconds by two in order to cover the charge and the discharge.

All this detail is not required. A simple paragraph on the characteristics of the capacitor under charge and discharge



1.2) Discrepancies during the practical carried out

< (fig 2)

The discrepancies will be down to mainly human error which may include starting the timer and recording the results as 20 second individuals up to 280 seconds at slightly different times which will give a little inaccurate reading. As well as that you may also find discrepancies involving the resistors in the circuit. Due to

resistors having tolerances this will give a slight inaccurate reading due to the fact that resistors typically have a 10% range, it could also be down to the temperature, operating voltage or the aging of the component. Overall these factors make the final outcome of the readings less accurate. The circuit under test conditions should show specific changes when the switch has been closed, these changes will be, when the time is recorded (560 seconds) on the charge of the capacitor you should see the values for the voltage over the capacitor should rise from zero to approximately six volts and the current should decrease in value which will make up the first 280 seconds. The discharge being carried out from 280 seconds to 560 seconds should then show the opposite of the readings in the charge values.

Good points here

1.3) Formula for instantaneous voltage

When ready to draw a graph matching the results gained from the practical you must create a capacitor voltage over time characteristic curve and a current over time characteristic curve. Both transient curves can be developed by using their specific mathematical equations which represent the circuit. To work out the transient curve for the voltage capacitor over time you use the formula: $V_c = V(1 - e^{-t/CR})$ or $V_c = V(1 - e^{-t/T})$. Generally when carrying out this formula for voltage specifically, you will notice the pattern that is when time increases the voltage increases. If a graph was plotted from a handful of times you'd expect to see a positive correlation. The 3 instantaneous times that I will using to record my data will be 40, 140 and 220 seconds.

1.4) Formula for instantaneous current

The formula derived from the current over time characteristic circuit can be written as $I = (I \times e^{-t/CR})$ or $I = (I \times e^{-t/T})$. In order to work out the current (IMAX) you must use the formula (V/R) . In order to work out the current/time graph you must use the formulas above to gain the time constant (T), use the method: $T = C \times R = 10000\mu F \times 5.6k\Omega = 56$ seconds

The transient period is the period in which the charge or discharge takes place. The either the current or voltage does one whole transient curve it is called the transient period in which where all the activity is happening: Transient period = $5 \times T = 5 \times 56$ seconds = 280 seconds

You can derive that as time increases the smaller the values of the charging capacitor for current gets. The 3 instantaneous times I will be using for the current time graph will be 40, 140 and 220 seconds

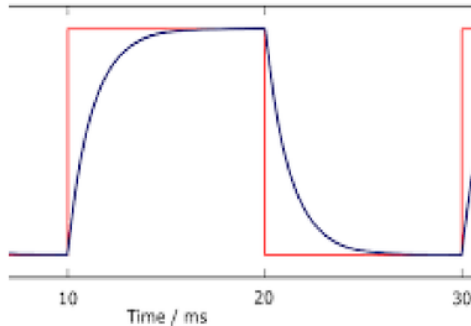
All this explanation is not necessary but these are the correct and

Good points introduction to the practical her

1.5) Transient period

Transient, meaning the changing values of the different graphs which will be the voltage capacitor over time graph, the voltage resistor over time graph and the current over time graph. In order to work out 5 tau (time constant), you must firstly work out the single time constant by using the equation $C \times R$ seconds

($10000 \times 10^{-6} \times 5.6 \times 10^{-3} = 56$ seconds) which will equal your first time constant. Once the time constant has been calculated it must then be multiplied by 5 in order to reach the maximum growth of the transient, this can be worked out like this 5×56 seconds ($5 \times 1T = 280$ seconds). The 5th time constant will be very close to the V_{max} . For a growth curve, the value of a transient equal to one time constant is taken as 63% of the steady state value or 0.63 in decimal form.



< (fig 3)

Figure 3 above shows what the charge and discharge of the capacitor should look like. The pulse displays both a curved and a straight plot. Both show the same results, however the blue (curved line) displays the more accurate results showing that the capacitor value rises over time of 280 seconds, which is noted as the transient period or the the rising curve or the pulse width. The pulse width of the 5 time constant (5T-280seconds) should only

cover the rise of the capacitor, it is important to know that as soon as the charge has finished that is the pulse width. The time period however is the width of both the rise and fall (Charge&discharge) of the graph, the time period will be displayed over 560 seconds (280x2). This is because the charge is 280 seconds therefore in order to work out both you have to double the charge of 280.

1.6) Practical results

	A	B	C
1	Table of results - CHARGE / DISC		
2	Time (t)	Vc (v)	Ic (mA)
3	20	1.91	0.701
4	40	3.09	0.491
5	60	3.91	0.352
6	80	4.47	0.25
7	100	4.89	0.179
8	120	5.18	0.127
9	140	5.39	0.094
10	160	5.54	0.069
11	180	5.64	0.051
12	200	5.72	0.038
13	220	5.77	0.028
14	240	5.81	0.022
15	260	5.84	0.016
16	280	5.86	0.013

< (fig 4)

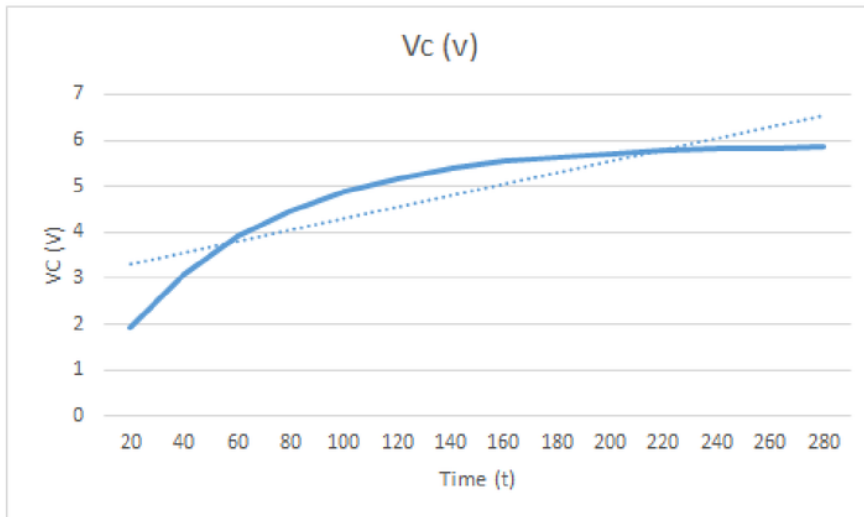
Good
explanation
of
test
methods

here.
This
shows
under
standing

Good set
of charge
results

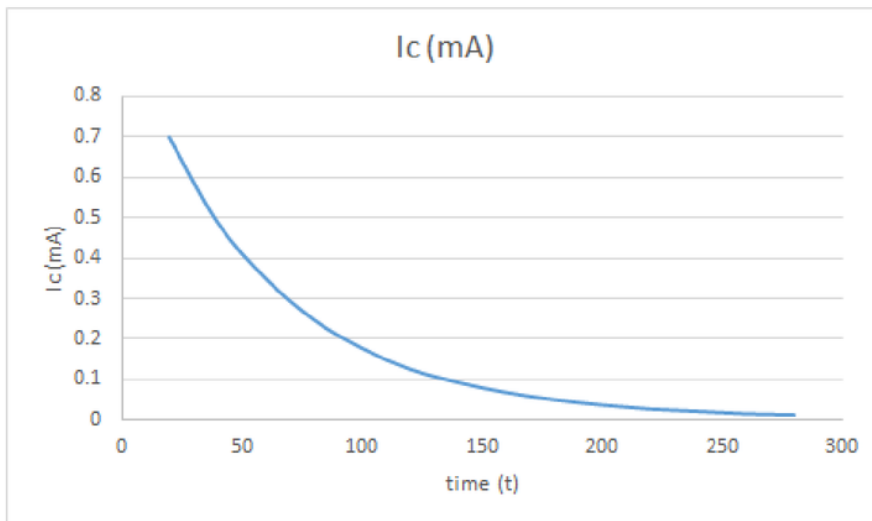
1.7) Graphs for charging V_c and I_c curves

Figure 6 shows the V/t graph giving the correlation required (positive). These graphs were derived from excel document. Figure 7 shows the results for the current/time characteristic graph. As shown the graph has a negative correlation.

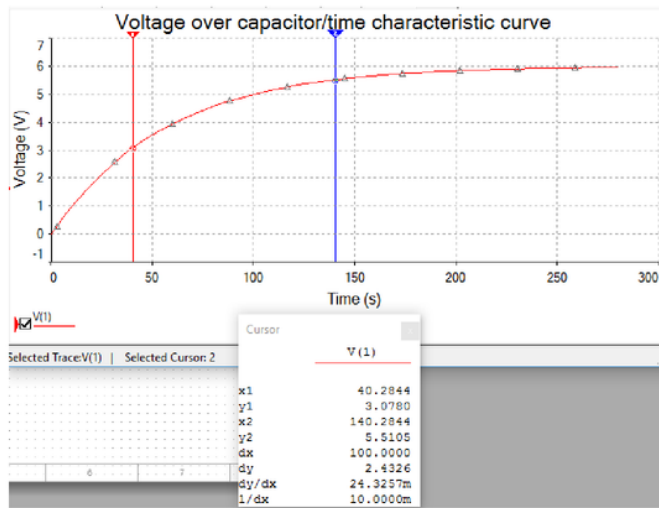


(Fig 6)

Graphs are good

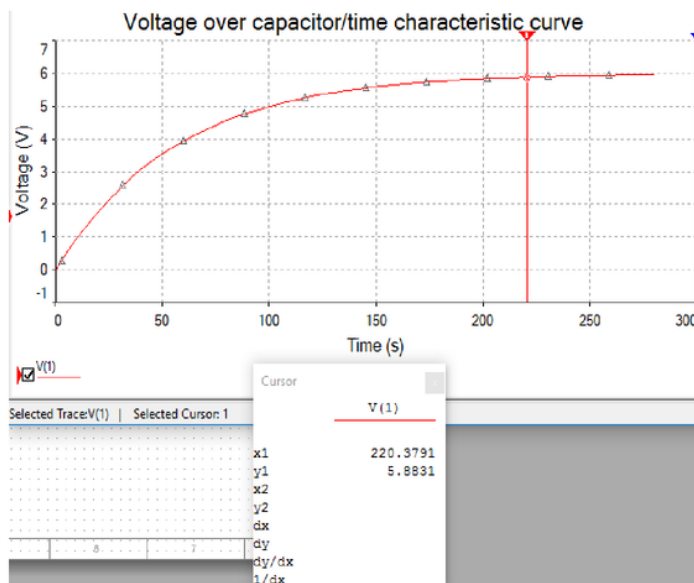


(Fig 7)



(Fig 8)

Figure 8 is a graph calculated from the multisim circuit which will give slightly more accurate results compared to the practical graphs. This is because the practical gives slight discrepancies like tolerance of resistors and human error, however the multisim method does not have this problem. Figure 8 and 9 gives you the results of a voltage capacitor / time graph. The data recorded is from my selected instantaneous voltage times which are 40 seconds, 140 seconds and 220 seconds.



(Fig 9)

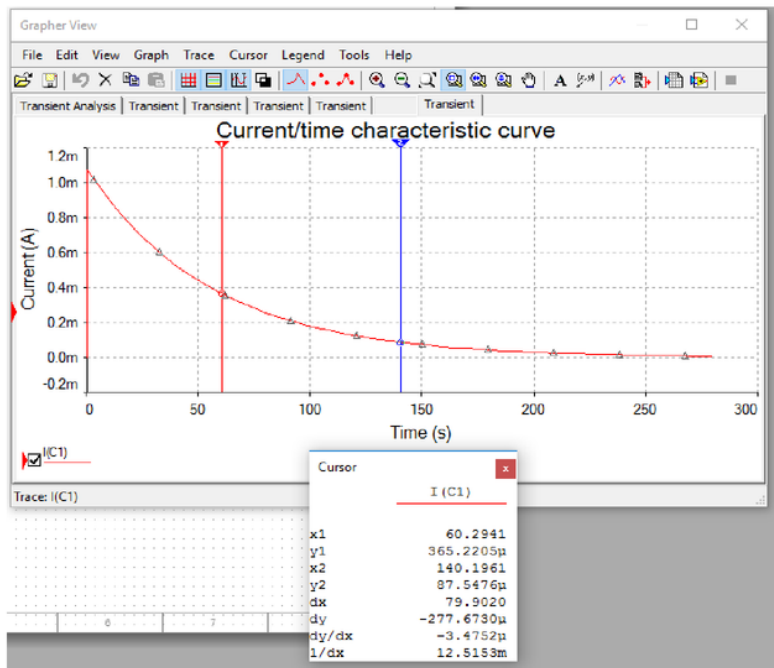


Fig 10

Figure 10 and 11 shows the multisim result of a current/time characteristic graph which displays the instantaneous current readings at 40, 140, and 220 seconds.

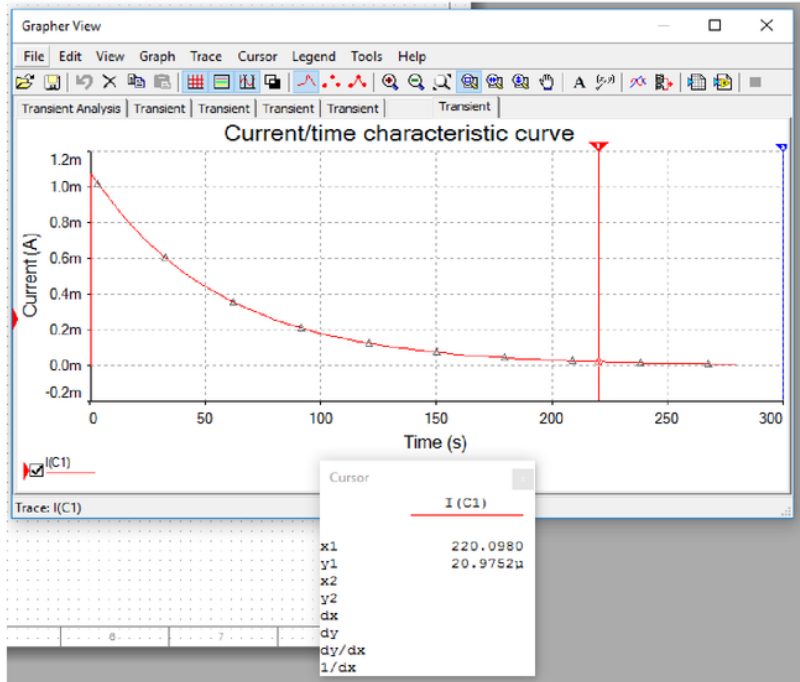


Fig 11

1.8) Explanation of graphs indicating any trends

You can compare all the graphs together and make sure that you see a pattern forming, each voltage, capacitor graphs should be similar and each current graphs should be similar. However you might see that the practical graphs are slightly different to the multisim graphs because the results are slightly less accurate. The capacitor charge graph values were recorded over 20 second intervals over 280 seconds. 280 seconds were recorded because this is the time needed for the capacitor to carry out its 5 time constants and the same time is needed for the current charge also. When studying the graphs figure 5 you can see that the transient period has been produced over 5 time constants and the steady state of the graph happens from 5 time constants onwards. By using a line of best fit you can find a positive correlation when the V_c is increasing furthermore you can spot the negative correlation when the current over time graph has been recorded. These results show this because as current is flowing through the circuit it is constantly filling the capacitor with charge meaning the V_c is growing in value, however the current is therefore starting from a high amount but is rapidly decreasing as time goes by because it is charging the capacitor. To conclude, when a capacitor is in its charging state you will gather that from the graphs and values displayed as time increases the V_c increases and the current decreases.

1.9) RC Charging Table

Time Constant	RC Value	Percentage of Maximum	
		Voltage	Current
0.5 time constant	$0.5T = 0.5RC$	39.3%	60.7%
0.7 time constant	$0.7T = 0.7RC$	50.3%	49.7%
1.0 time constant	$1T = 1RC$	63.2%	36.8%
2.0 time constants	$2T = 2RC$	86.5%	13.5%
3.0 time constants	$3T = 3RC$	95.0%	5.0%
4.0 time constants	$4T = 4RC$	98.2%	1.8%
5.0 time constants	$5T = 5RC$	99.3%	0.7%

This shows a good characteristic

https://www.electronics-tutorials.ws/rc/rc_1.html ^ (Fig 12) ^

Figure 12 is a table containing the significant points that are crucial in the development of any characteristic graph. The table illustrates each individual time constant and the RC values to go with, it also gives you the specific percentage needed for the maximum voltage and current. We can now work out that the time constants from 0.5 tau to 5 tau is the transient state or the growth in changing values and 5 tau onwards gives the steady state value meaning the capacitor is fully charged and therefore the current has depleted to nothing.

1.10) Comparison table (CHARGE)

The formula used for VC/t is $V_c = V(1 - e^{-t/T})$

- V_c at 60 seconds = $6(1 - e^{-0.60/0.56}) = 3.944886869$
= 3.945volts (3d.p)
- V_c at 140 seconds = $6(1 - e^{-1.40/0.56}) = 5.507490008$
= 5.507volts (3d.p)
- V_c at 220 seconds = $6(1 - e^{-2.20/0.56}) = 5.88196947$
= 5.882volts (3d.p)

The pattern reached is, as time increases the voltage increases.

Voltage results			
Time (seconds)	Calculated	Simulated (Multisim)	Practical
60	3.945 V	3.951 V	3.91 V
140	5.507 V	5.511 V	5.39 V
220	5.882 V	5.883 V	5.81 V

Good calcs here and good use of table for comparisons

The equation used to work out the instantaneous reading for the current on the charge is as follows:
($I \times e^{-t/T}$).

- Current at 60 seconds = $1.0714285 \times e^{-0.60/0.56} = 0.3669844876$
= 0.367mA (3d.p)
- Current at 140 seconds = $1.0714285 \times e^{-1.40/0.56} = 0.08794820695$
= 0.088 mA (3d.p)
- Current at 220 seconds = $1.0714285 \times e^{-2.20/0.56} = 0.02107687895$
= 0.021mA (3d.p)

Current readings			
Time (seconds)	Calculated	Simulated (Multisim)	Practical
60	0.367 mA	0.365 mA	0.352 mA
140	0.088 mA	0.087 mA	0.094 mA
220	0.021 mA	0.020 mA	0.022 mA

Results look good and a good comparison is shown here

Task 2: Transient Behaviour for the Discharging of a Capacitor

2.1) Practical results

Fig 13

E	F	G	H
Time (t)	Vc (v)	Ic (mA)	
300	4.09	-0.705	
320	2.92	-0.506	
340	2.05	-0.357	
360	1.45	-0.253	
380	1.04	-0.181	
400	0.75	-0.129	
420	0.53	-0.092	
440	0.38	-0.066	
460	0.27	-0.047	
480	0.2	-0.034	
500	0.14	-0.025	
520	0.1	-0.018	
540	0.08	-0.013	
560	0.05	-0.01	

*Good
results
obtained
from
test*

2.2) Graphs for discharging Vc and Ic curves

Fig 15

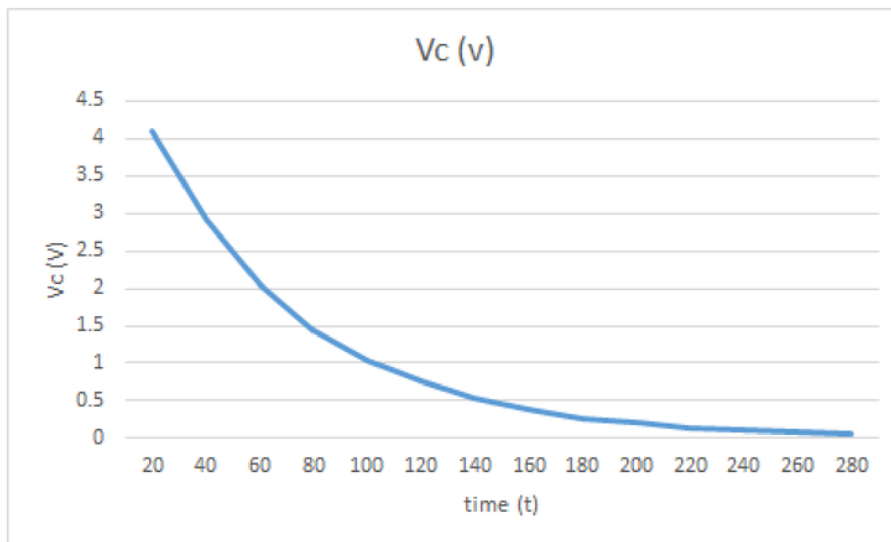
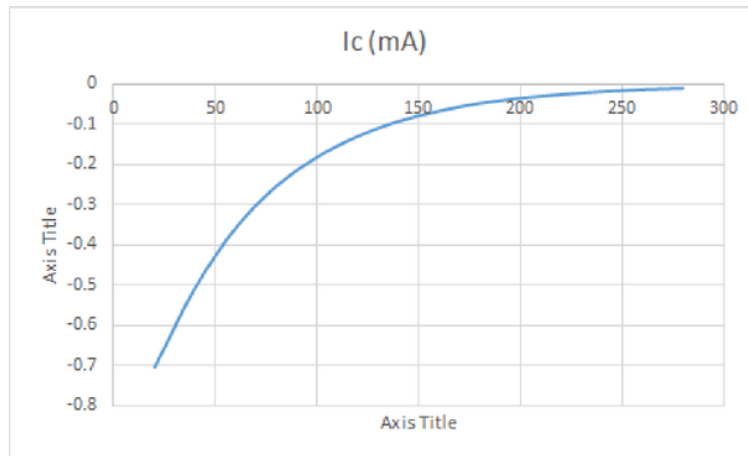


Fig 16



Good graphs showing characteristics for discharge. When using excel sometimes it is best to use text for naming the axis on the graphs.

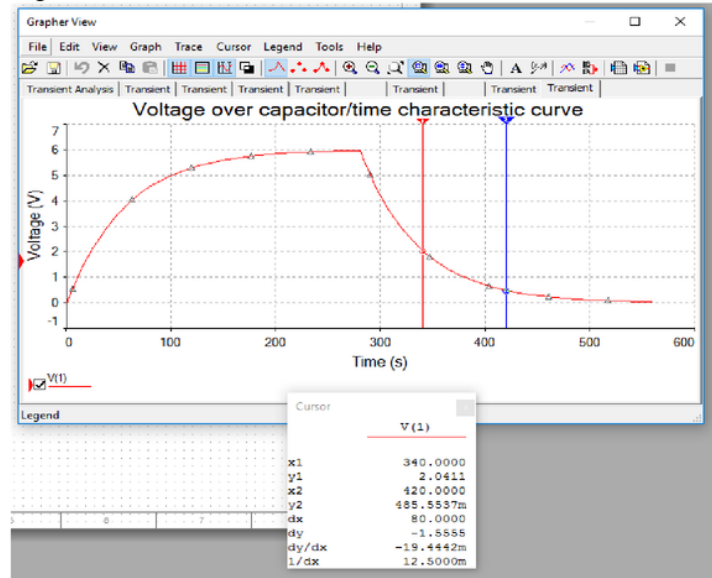
2.3) Explanation of graphs

The graphs labelled as figure 8 shows the important values used in the graph and gives a good idea of what you're calculated graphs should look like when you use the results sourced from the practical in figure 2. The above graphs show the discharge of the capacitor. Two discharge graphs have been calculated and constructed which display the voltage over the capacitor and the current flowing in the circuit. From the graphs you can see that the voltage over the capacitor gives a negative correlation which is the opposite of the charge graph. The current discharge graph shows a positive correlation in the circuit meaning that the current is rising and is the opposite of the charging results. Furthermore you can conclude by saying when the switch in the circuit goes negative the capacitor will also go negative but you will then see your IMAX, this can be described as a battery.

Good explanation

2.4) Multisim of practical discharge

Fig 17



The Voltage over capacitor / time characteristic curve is displayed below. The graph was drawn using the multisim program and highlights 2/3 of the instantaneous V_c voltages which are shown by x1(340 seconds) and y1 (2.0411 volts), 340 being equivalent to 60 seconds at discharge (280 seconds/charge+60 seconds). Then at 420 seconds (140 seconds) displayed by x2 and y2 (485.5537m).

Good graphs from ECAD

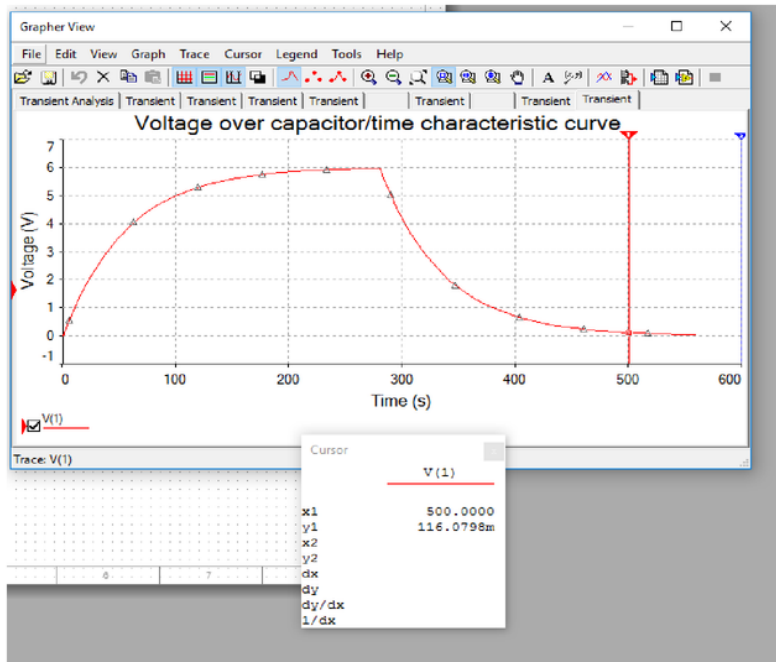
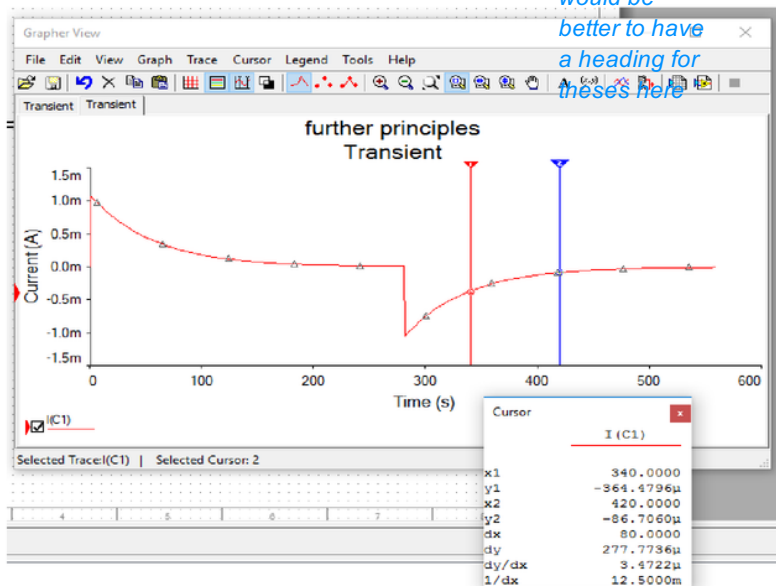


Fig 18

Figure 18 above shows the third and final instantaneous voltage needed for the Vc. This has been highlighted by x1 and y1 (500 seconds and 116.0798).

Fig 19

The graphs are now for current and would be better to have a heading for these here



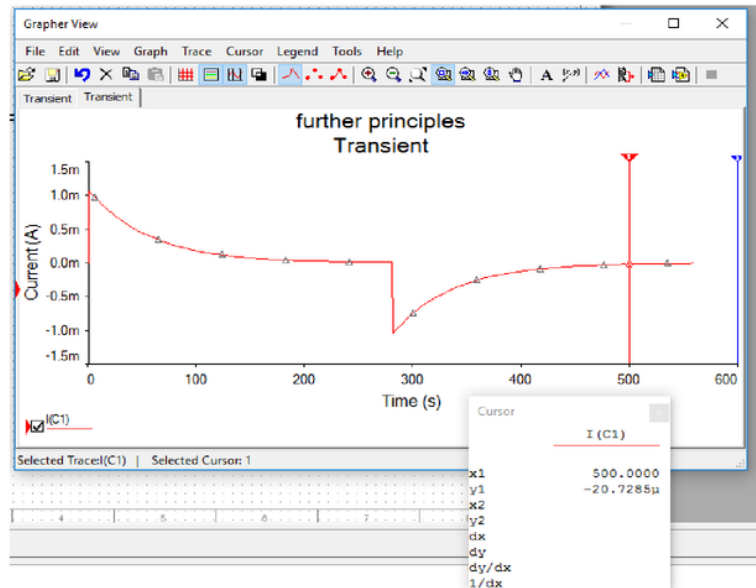


Fig 20

The multsim (fig 19) shown is a Current / time characteristic curve which shows the discharge process for the current. Indicated by the graph you can see that the current increases when the capacitor discharges. The $\frac{2}{3}$ instantaneous current values are noted as x1 and y1 (340 seconds and -364.4796µ) and by x2 and y2 (420 seconds and -86.7060µ). Fig 20 also shows a current / time characteristic curve however, this graph shows the third instantaneous value indicated by x1 and y1 (500 seconds and -20.7285µ)

2.5) Comparison table (DISCHARGE)

Voltage readings			
Time (seconds)	Calculated	Simulated (Multsim)	Practical
340	2.055 V	2.041 V	2.05 V
420	0.493 V	0.486 V	0.53 V
500	0.118 V	0.116 V	0.14 V

Table of values look good

Formula: $V = V \times e^{-(t/T)}$

Simultaneous current values at:

60 seconds: $6 (e^{0.60 / 0.56}) = 2.055113131$
 $= 2.055 \text{ Volts}$

140 seconds: $6 (e^{1.40 / 0.56}) = 0.4925099917$
 $= 0.493 \text{ Volts}$

220 seconds: $6 (e^{2.20 / 0.56}) = 0.11803053$
 $= 0.118 \text{ Volts}$

C
a
l
c
u
l
a
t
e
d
v
a
l
u
e
s

Current readings			
Time (seconds)	Calculated	Simulated (Multisim)	Practical
340	-0.367	-0.364	-0.357
420	-0.088	-0.086	-0.092
500	-0.021	-0.020	-0.025

Good set of results

Formula: $I = -I \times e^{-t/T}$

Simultaneous current values at:

60 seconds: $-1.0714285 \times e^{-0.60 / 0.56} = -0.3669844631$
 $= -0.367\text{mA}$

140 seconds: $-1.0714285 \times e^{-1.40 / 0.56} = -0.08794820695$
 $= -0.088\text{mA}$

Calcs are accurate

220 seconds: $-1.0714285 \times e^{-2.20 / 0.56} = -0.02107687895$
 $= -0.021\text{mA}$

From the comparison tables shown above giving the calculated, simulated and the practical values at 3 instantaneous times for the voltage and current at a discharging rate you can see that all values are very similar, however there is slight differences with the results but they are all relevantly close meaning that the values are true. When talking about the data gathered you should not be surprised to see the practical readings being the least accurate, due to many discrepancies like tolerances and human error. From the data in the table showing the voltages over the capacitor you should see the values decreasing over time, however when looking at the current discharge the values should be increasing as time goes by, this is because when the capacitor is discharging it is losing all the electrons that were being stored inside and are now being released, because of this more and more electrons over time begin to flow back around the circuit and back to the power supply making the current increase over time, so as a result when the capacitor is losing electrons the voltage is decreasing and because of this the current increases which gives you the shape you get in the multisim graphs.

There is no need for such an extensive explanation, a table of comparison and arguments would be enough. There are good points here all the same.

Task 3: Transient behaviour for a complex circuit

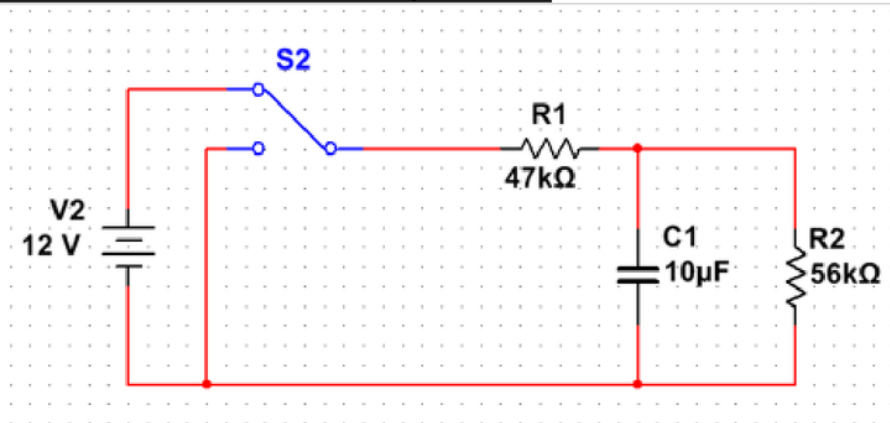


Fig 21

3.1) Task overview

This task is a more complex circuit compared to the RC circuit carried out on the previous tasks above. The difference with this circuit is that it contains 2 resistors instead of one, meaning different principles must be carried out in order to gain the specific values required. For this circuit different values have been used meaning a different set of values compared to the task 1 and task 2. The task will involve me carrying out a thorough investigation into complex RC circuits. The time constant (RC) will be calculated using formula to predict instantaneous values of Voltage and Current and I will break down the circuit to an equivalent circuit in order to carry out my investigation. During this task, I will:

- Require the time constant (T) by using the values of $R \times C$.
- Find 3 instantaneous voltages at "random times" using the equation $V_c = V [1 - e^{-t/T}]$

Do not use first person terms in any report. Avoid giving a diary of the actions carried out. Assumptions can be made.

3.2) Initial and Final condition of capacitor

- The initial condition of the capacitor which will be in its high state value is the short circuit. Furthermore meaning that R2 is bypassed so therefore

$$I_{MAX} \text{ (initially)} = V / R1 \text{ initial condition} \\ = 12 / 47 = 0.25\text{mA}$$

- The final condition of the capacitor when there is no current, meaning when the circuit is open it now allows R2 to be active in the circuit, therefore the final condition is worked out to be

$$I_{MAX} \text{ (final)} = V / R1 + R2 \text{ final condition} \\ = 12 / 47 + 56 = 0.11\text{mA}$$

This is correct for initial and final currents in the circuit

3.3) Final result (Step 1)

Figure 22 shows what the circuit should look like without the capacitor. The circuit however still includes the power supply of 12 volts and the resistors labelled as R1 (47kΩ) and R2 (56kΩ).

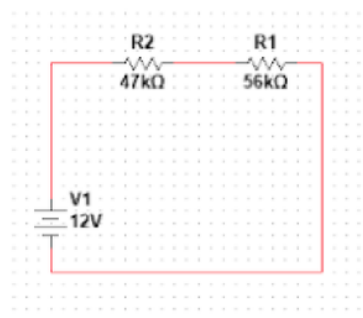
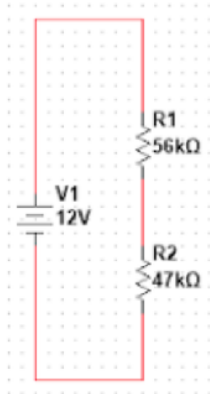


Fig 22

3.4) Equivalent circuit (Step 2)

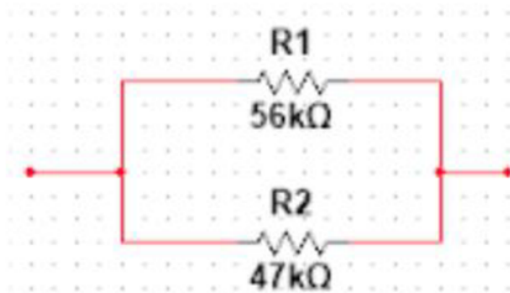
Fig 23



The image labelled figure 23 above is the same as the final result circuit however it is now in parallel instead. In order to continue with the sequence of steps to get your overall equivalent circuit you must now remove the power supply out of the circuit, and you are then left with figure 24 shown below.

3.5) Removing power supply (Step 3)

Fig 24

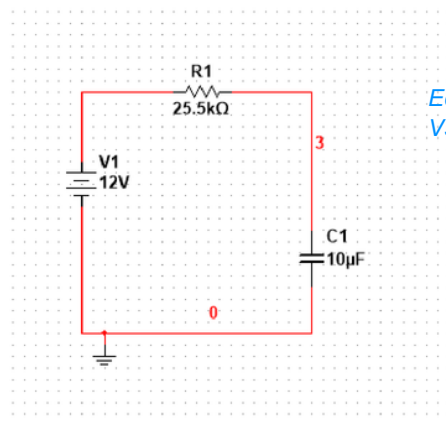


3.6) Reduction of parallel circuit (Step 4)

From figure 5 you must now reduce the parallel circuit and combine the resistors to make a resistor total (RT). This is done by using the following formula

- $$RT = \text{product} / \text{sum} = R1 \times R2 / R1 + R2$$
$$= 47 \times 56 / 47 + 56$$
$$= 25.5K\Omega$$

Now, from the RT given you can now alter the complex circuit from the beginning by removing the 2 resistors and replacing them with the new resistor value of RT (25.5KΩ). The circuit can be shown as figure 25.



*Equivalent circuit
Vs is not 12v here*

Fig 25 >

3.7) Calculating the new Voltage supply (Step 5)

Fig 26

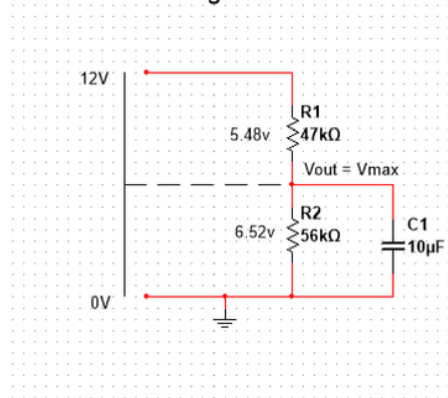
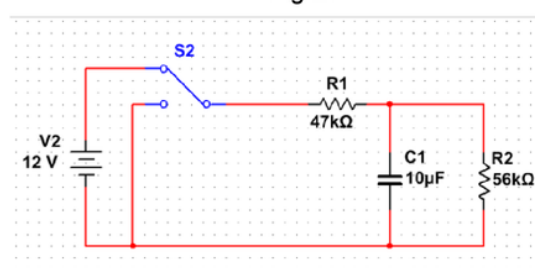


Fig 27



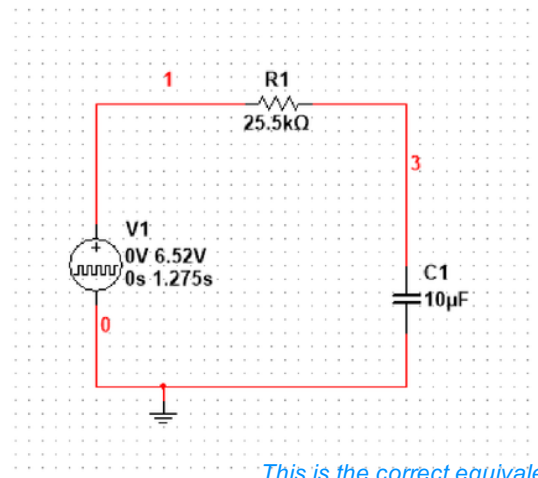
This method is correct

The complex circuit above (figure 26) can also be drawn in another way called a voltage divider (figure 27) in which it can allow you to calculate the output voltage from the circuit instead.

The equation used for $V_{out} = V_{cmax} = V_s \times R_2 / R_1 + R_2$
 $= 12 \times 56 / 47 + 56$
 $= 6.52V$

3.8) New equivalent circuit

Fig 28



This is the correct equivalent circuit

From figure 28 you can now use the results gained to calculate further equations to complete your report on this task. You must first work out the time constant (T), the total resistance (RT), the capacitance (C1) and the five time constants (5T).

$$1) T = R \times C$$

$$= 25.5 \times 10^3 \times 10 \times 10^{-6}$$

$$= 0.255 \text{ seconds}$$

$$2) R_T = \text{product} / \text{sum} = R_1 \times R_2 / R_1 + R_2$$

$$= 47 \times 56 / 47 + 56$$

$$= 25.5K\Omega$$

$$3) C = 10\mu F$$

$$4) 5T = 5 \times 0.255 = 1.275 \text{ seconds}$$

$$5) \text{Pulse width} = \text{total width of charge in seconds} = 1.275 \text{ seconds}$$

$$6) \text{Period} = \text{total width of charge and discharge (p.w} \times 2) = 2.55 \text{ seconds}$$

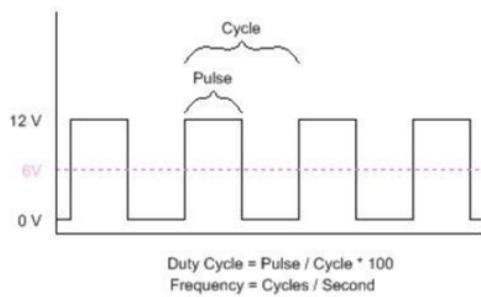


Fig 29

3.9) 3 Instantaneous values for voltage at a charging rate

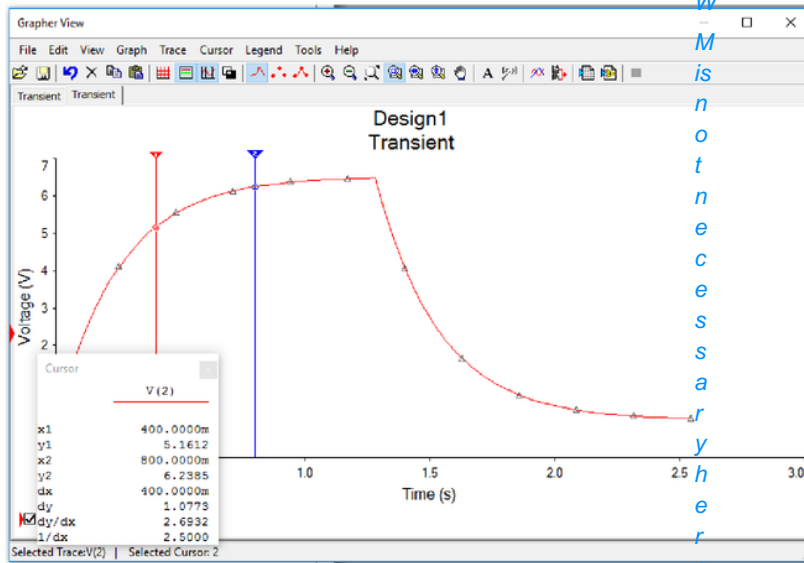
The random times that I have selected to add to my instantaneous voltage equation ($V_c = V_{max} [1 - e^{-t/T}]$) are:

1. The voltage at 0.4 seconds : $V_c = 6.52 [1 - e^{-0.4 / 0.255}]$
 $= 5.161682332$
 $= 5.162 \text{ volts (3.d.p)}$
2. The voltage at 0.8 seconds : $V_c = 6.52 [1 - e^{-0.8 / 0.255}]$
 $= 6.237020416$
 $= 6.237 \text{ volts (3.d.p)}$
3. The voltage at 1.1 seconds : $V_c = 6.52 [1 - e^{-1.1 / 0.255}]$
 $= 6.432738953$
 $= 6.433 \text{ volts (3.d.p)}$

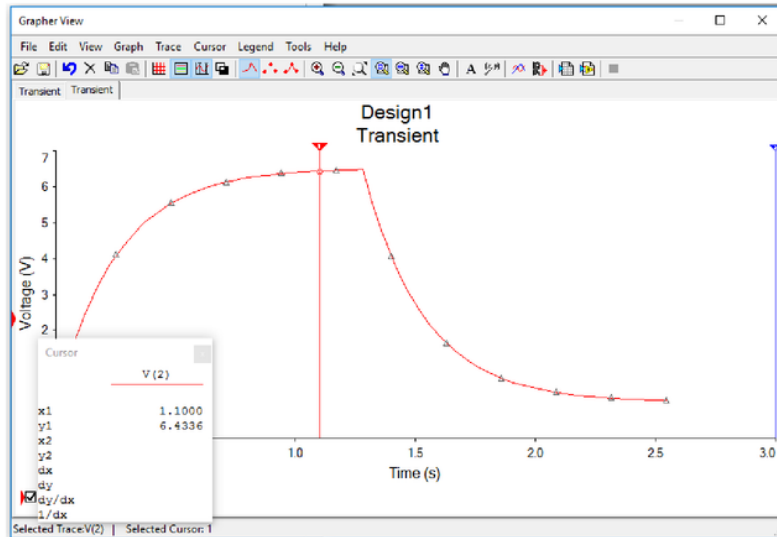
3.10) Transient graph for voltage at 3 instantaneous times selected (Charge)

X1 = 0.4s y1 = 5.161

X2 = 0.8s y2 = 6.239



$x1 = 1.1s$ $y1 = 6.434$



3.11) 3 Instantaneous values for current at a charging rate

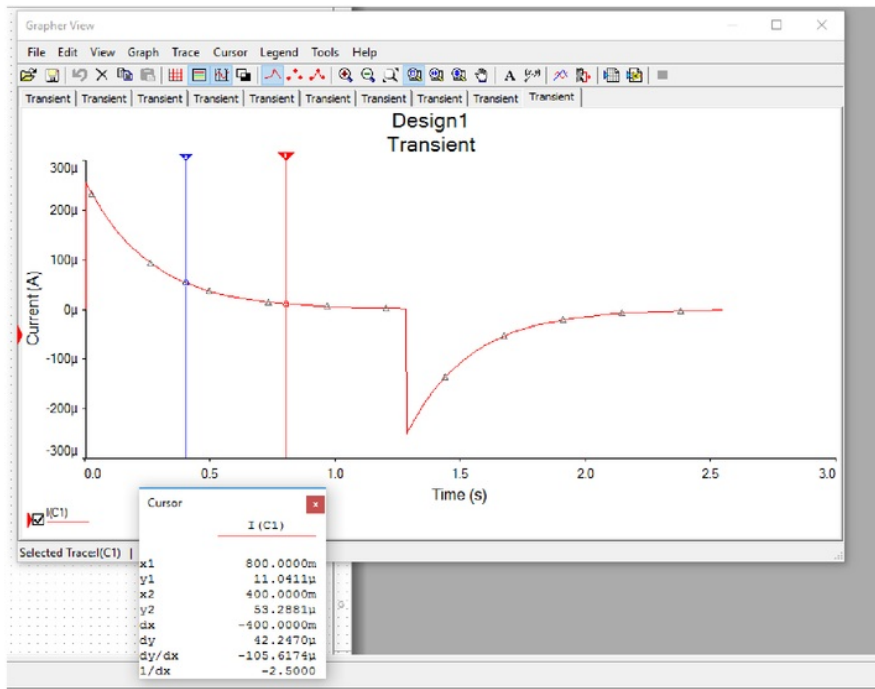
The random times that I have selected to add to my instantaneous current equation ($I_c = I_{max} [e^{-t / T}]$) are:

1. The current at 0.4 seconds : $I_c = 0.25 [e^{-0.4 / 0.255}]$
 $= 0.05208273266$
 $= 0.052mA$ (3.d.p)
2. The current at 0.8 seconds : $I_c = I_{max} [e^{-0.8 / 0.255}]$
 $= 0.01085044416$
 $= 0.011mA$ (3.d.p)
3. The current at 1.1 seconds : $I_c = I_{max} [e^{-1.1 / 0.255}]$
 $= 3.345899036 \times 10^{-3}$
 $= 0.003mA$ (3.d.p)

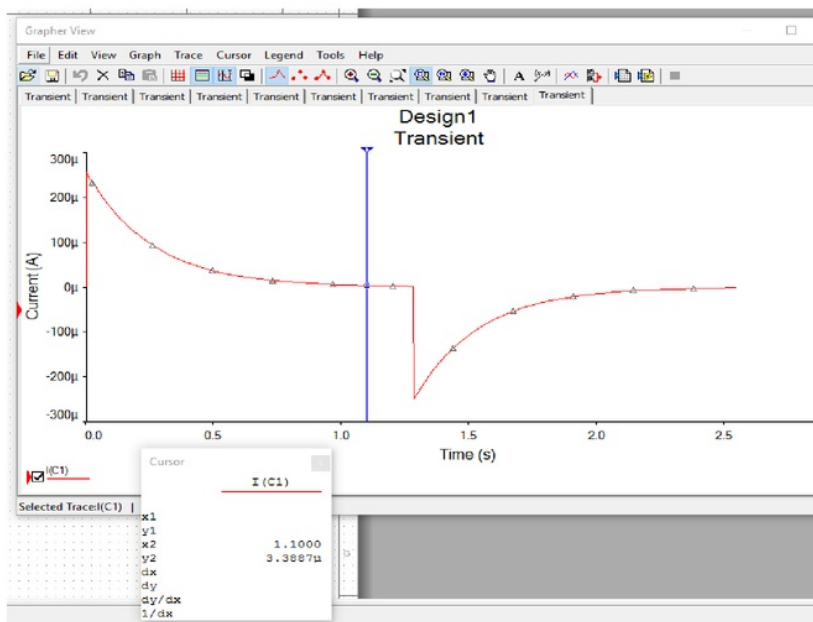
3.12) Transient graph for current at 3 instantaneous times selected (Charge)

$x_2 = 0.4\text{s}$ $y_2 = 0.053$

$x_1 = 0.8\text{s}$ $y_1 = 0.011$



$x_2 = 1.1\text{s}$ $y_2 = 0.003$



Discharge for Complex circuit

3.13) 3 Instantaneous values for voltage at a discharging rate

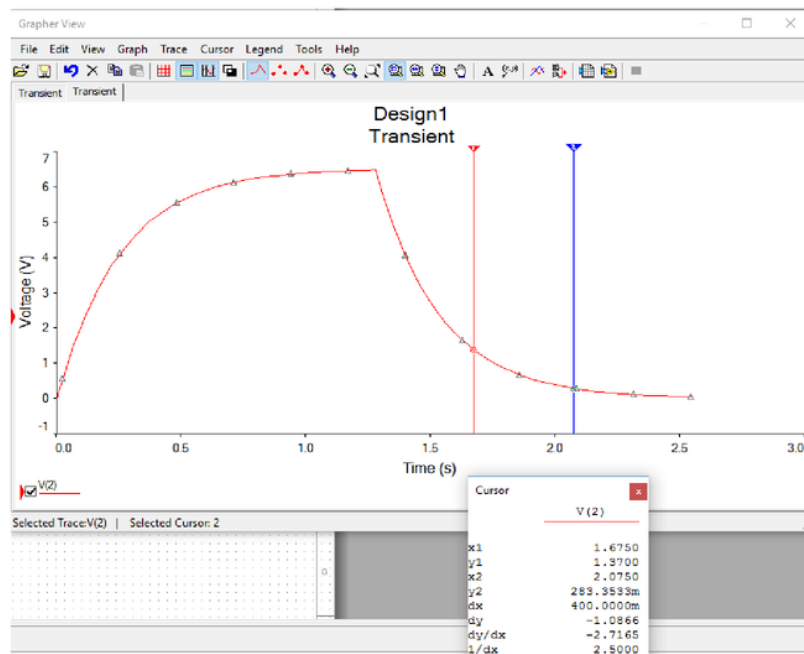
The equation that I will be using to calculate my transient values will be
 $V_c = V (e^{-t/T})$

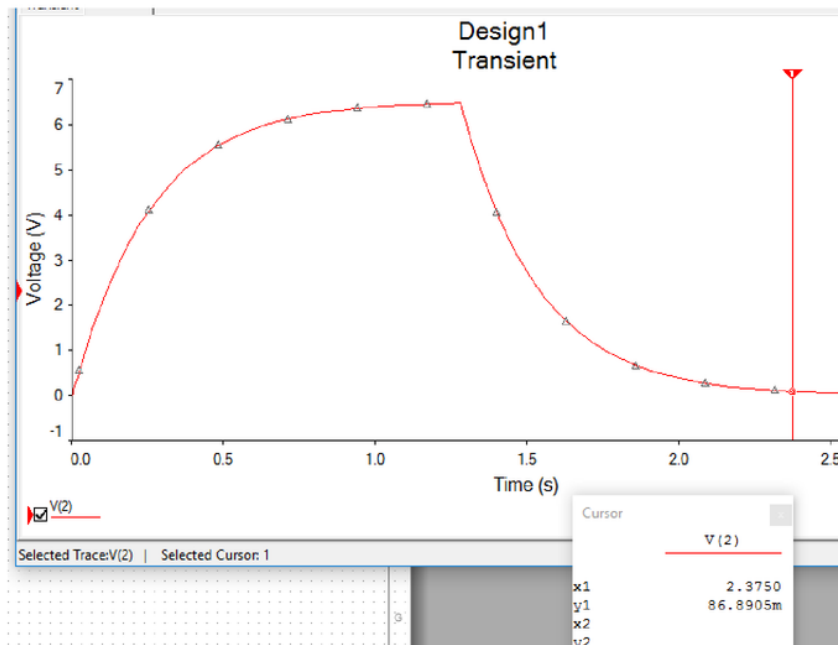
1. The voltage at 0.4 seconds : $V_c = 6.52 (e^{-0.4 / 0.255})$
= 1.358317668
= 1.358 volts (3.d.p)
2. The voltage at 0.8 seconds : $V_c = 6.52 (e^{-0.8 / 0.255})$
= 0.2829795838
= 0.283 volts (3.d.p)
3. The voltage at 1.1 seconds : $V_c = 6.52 (e^{-1.1 / 0.255})$
= 0.08726104687
= 0.087 volts (3.d.p)

3.14) Transient graph for voltage at 3 instantaneous times selected (discharge)

$x_1 = 1.675s$ $y_1 = 1.370$

$x_1 = 2.375s$ $y_1 = 0.086$





3.15) 3 Instantaneous values for current at a discharging rate

The equation that I will be using to calculate my transient values will be: $I_c = -I_{max} (e^{-t/T})$

1. The current at 1.675 (0.4) seconds : $I_c = -0.25 (e^{-0.4 / 0.255})$
 $= -0.05208273266$
 $= -0.052\text{mA} (3.d.p)$
2. The current at 2.075 (0.8) seconds : $I_c = -0.25 (e^{-0.8 / 0.255})$
 $= -0.01085044416$
 $= -0.011\text{mA} (3.d.p)$
3. The current at 2.375 (1.1) seconds : $I_c = -0.25 (e^{-1.1 / 0.255})$
 $= -3.345899036 \times 10^{-3}$
 $= -0.003\text{mA} (3.d.p)$

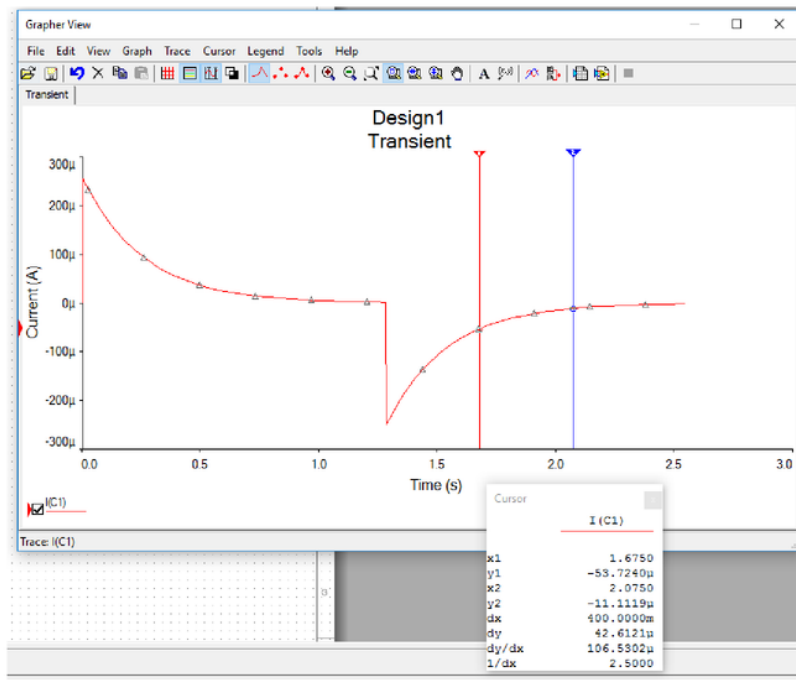
3.16) Transient graph for current at 3 instantaneous times selected (discharge)

x1 = 1.675

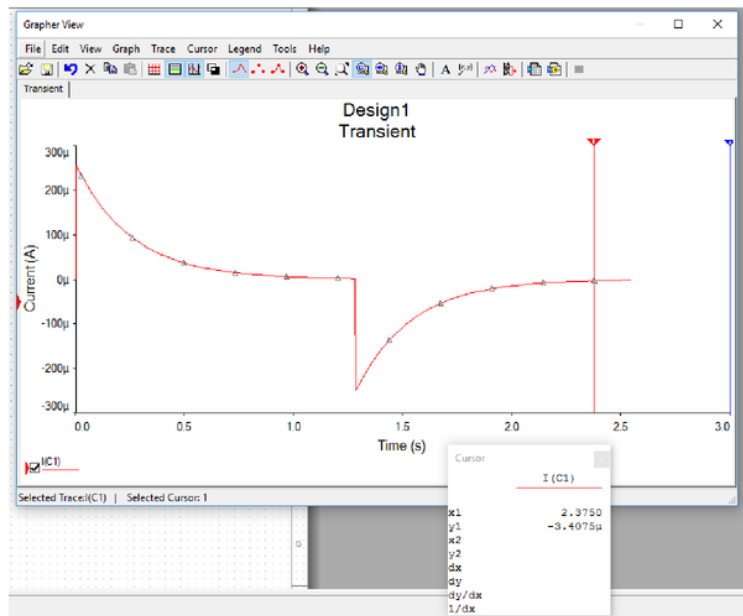
x2 = 2.075

y1 = -0.053

y2 = -0.011



x1 = 2.375s y1 = -0.034



3.17) Table of values for charge and discharge

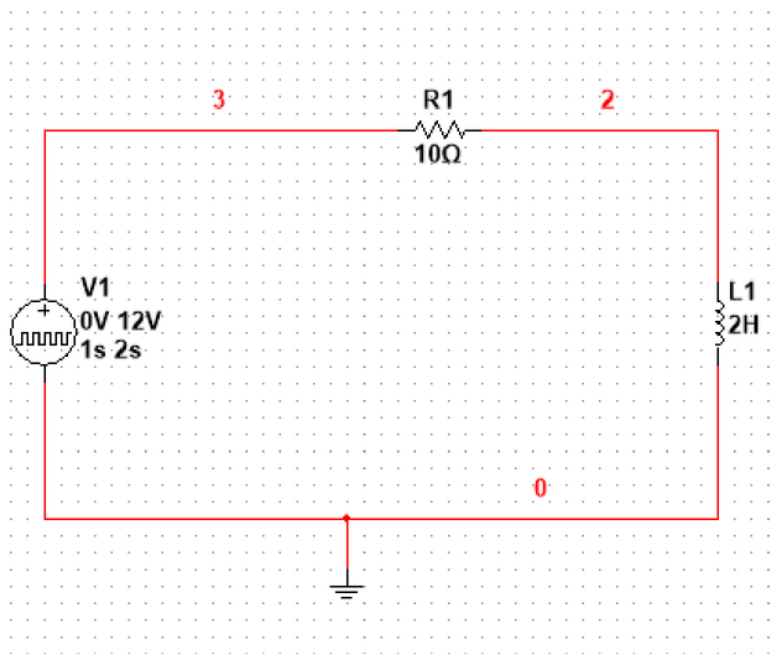
Time (s)	Charge Calculated		Discharge Calculated		Charge multsim		Discharge multsim	
	Voltage (v)	Current (mA)	Voltage (v)	Current (mA)	Voltage (v)	Current (mA)	Voltage (v)	Current (mA)
0.4 s	5.162	0.052	1.358	-0.052	5.161	0.053	1.370	-0.053
0.8 s	6.237	0.011	0.283	-0.011	6.239	0.011	0.283	-0.011
1.1 s	6.433	0.003	0.087	-0.003	6.434	0.003	0.086	-0.034

This value should be -0.003mA

The significant points of the transient could have been highlighted in the above analysis of the circuit

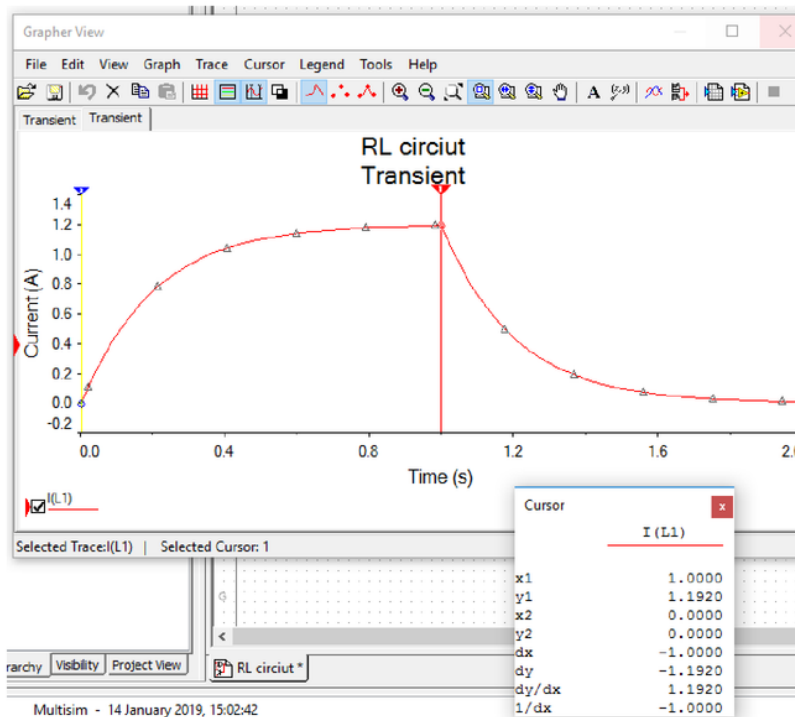
Task 4: Transient behaviour for a inductive circuit

Multisim of RL circuit



Good diagram of test setup

4.1) Simulation of the current growth for the first one second after the voltage source is applied to the circuit



Calculated

$$I_L \text{ at } 1 \text{ second} = I_L = 1.2 [1 - e^{-10/2 \times 1}] = 1.191914464$$

$$I_{MAX} = V_{max} / R$$

$$I_{MAX} = 12 / 10 = 1.2$$

This is good here but what about time constant and transient period. You would have to know these for the ECAD tests.

4.2) Carrying out calculations and manually plotting the current

5 calculated results using the times in seconds displayed in the table below.

(IMAX=Vs/R = 12/10 = 1.2A)

$$\begin{aligned} 1. \quad 0.1\text{secs} &= IL = I_{\text{max}}[1 - e^{-R/L \times t}] \\ &= 1.2[1 - e^{-10/2 \times 0.1}] \\ &= 0.7278367917 \\ &= 0.728 \text{ (3.d.p)} \end{aligned}$$

$$\begin{aligned} 2) \quad 0.3\text{secs} &= IL = I_{\text{max}}[1 - e^{-R/L \times t}] \\ &= 1.2[1 - e^{-10/2 \times 0.3}] \\ &= 0.2677561922 \\ &= 0.268 \text{ (3.d.p)} \end{aligned}$$

$$\begin{aligned} 3) \quad 0.5\text{secs} &= IL = I_{\text{MAX}} [1 - e^{-R/L \times t}] \\ &= 1.2[1 - e^{-10/2 \times 0.5}] \\ &= 0.09850199835 \\ &= 0.099 \text{ (3.d.p)} \end{aligned}$$

$$\begin{aligned} 4) \quad 0.7\text{secs} &= IL = I_{\text{MAX}} [1 - e^{-R/L \times t}] \\ &= 1.2[1 - e^{-10/2 \times 0.7}] \\ &= 0.03623686011 \\ &= 0.036 \text{ (3.d.p)} \end{aligned}$$

$$\begin{aligned} 5) \quad 0.9\text{secs} &= IL = I_{\text{MAX}} [1 - e^{-R/L \times t}] \\ &= 1.2[1 - e^{-10/2 \times 0.9}] \\ &= 0.01333079585 \\ &= 0.013 \text{ (3.d.p)} \end{aligned}$$

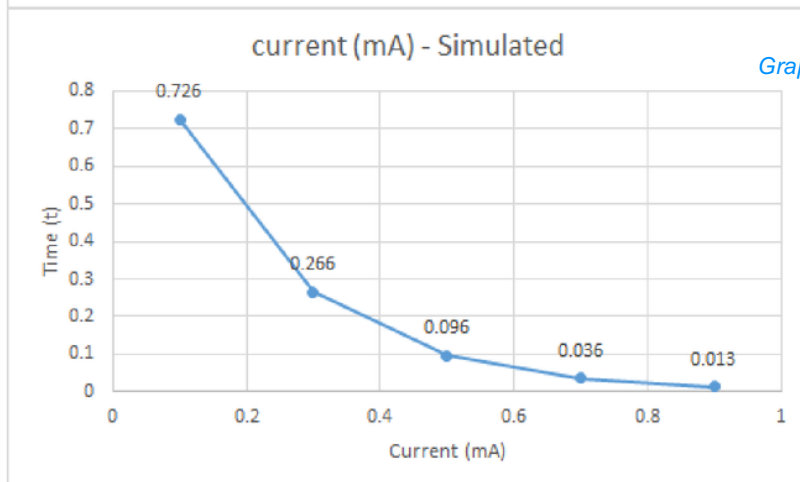
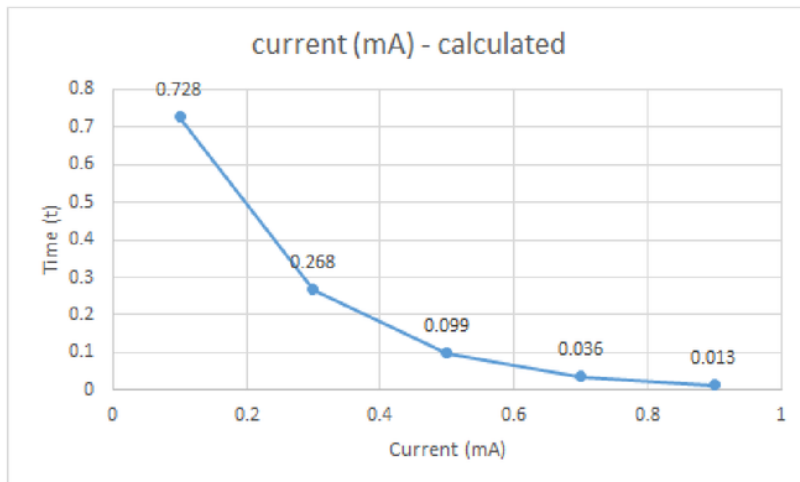
*These
calcs look
good*

4.3) Comparing simulation and calculated results

The 5 times chosen for the calculated and simulated equations

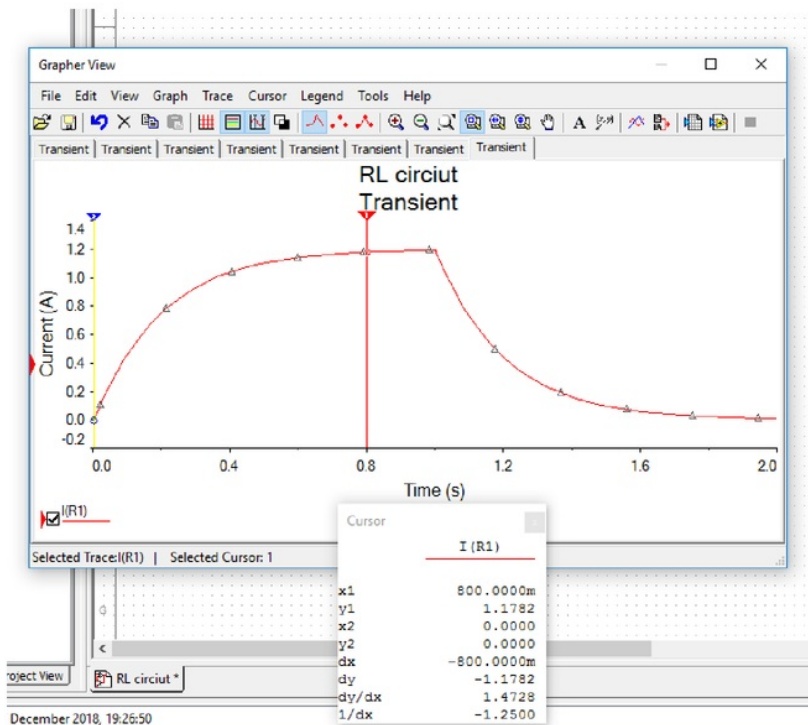
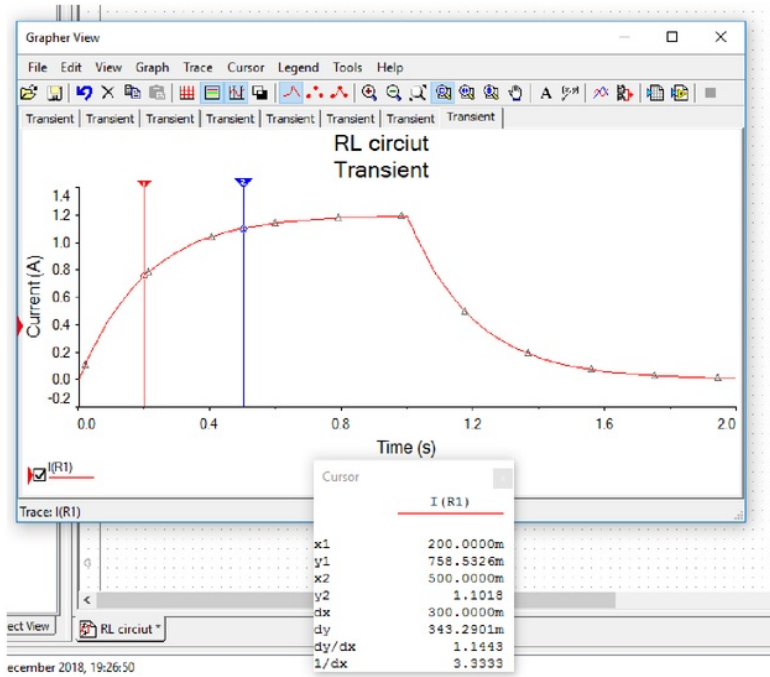
	Calculated	Simulated
Time (seconds)	Current (mA)	Current (mA)
0.1	0.7278367917	0.725782
0.3	0.2677561922	0.2660977
0.5	0.09850199835	0.0975641
0.7	0.03623686011	0.0357717
0.9	0.01333079585	0.0131156

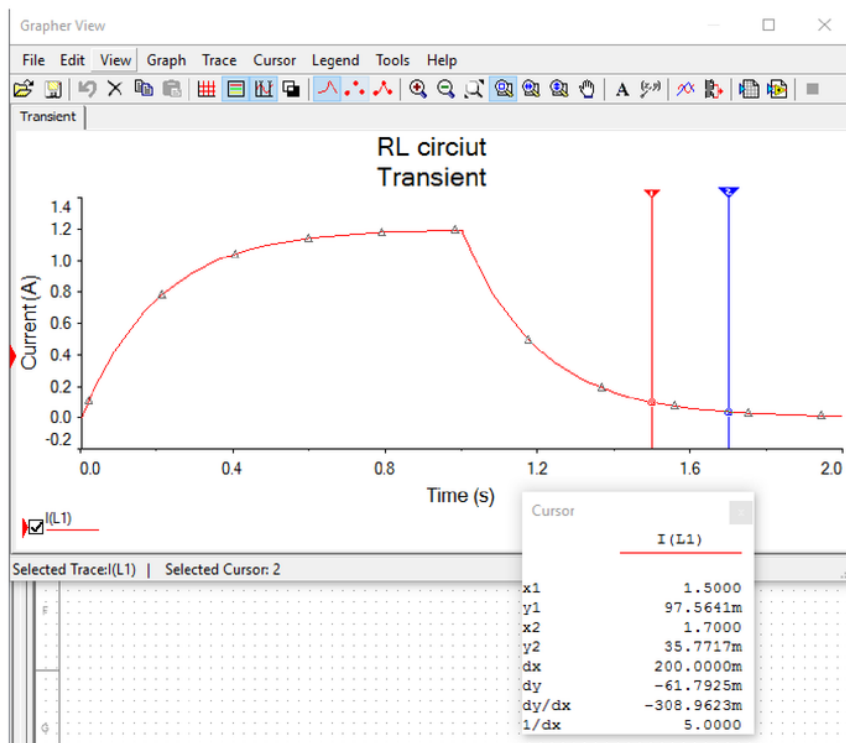
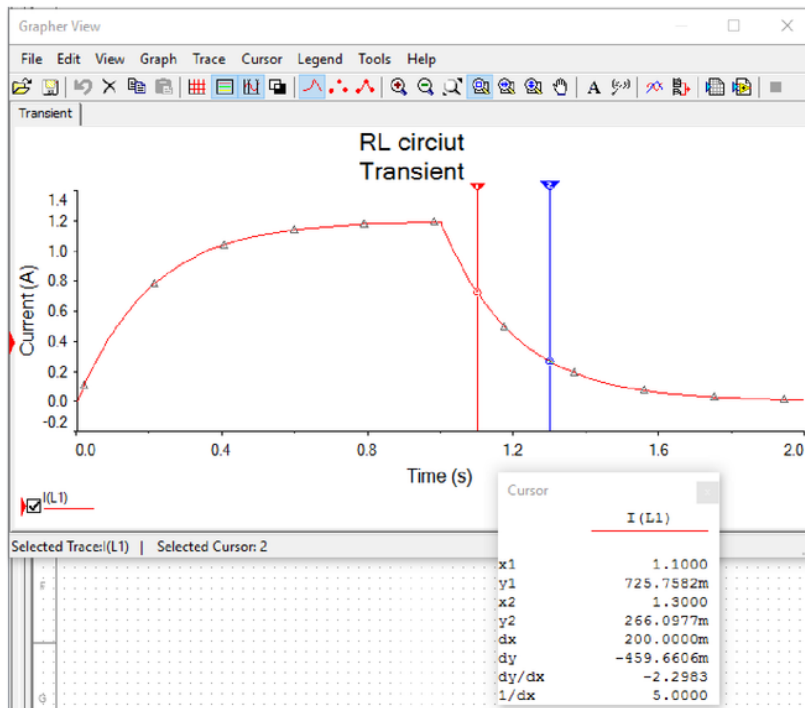
*Good table of
comparison*

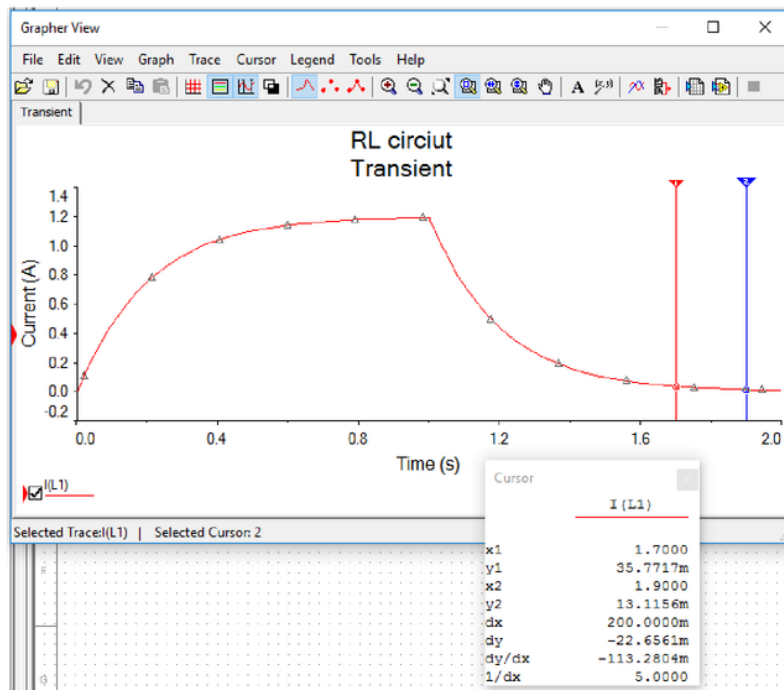


Graphs look good

Simulated graphs to show the 5 different times chosen and what they display in current.







Good analysis

4.4) Current flowing in the circuit immediately before the switch is changed over

Final value for current is $I_{MAX} = V_s / R = 12 / 10 = 1.2A$

This is correct here

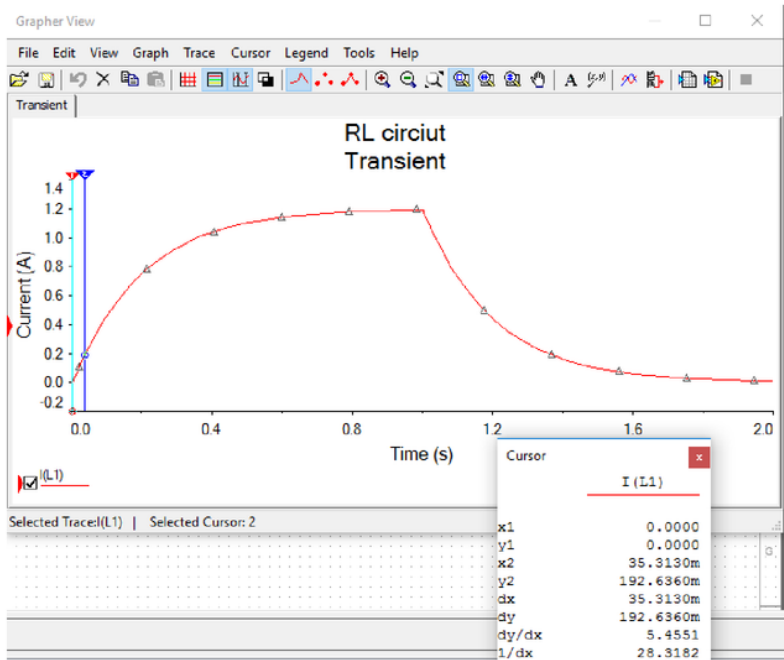
Immediately before the switch is changed at 1 second, you must use specific formulae to work out the current at 1 second, therefore $I_L = I_{MAX} [1 - e^{-R/L \times t}]$
 $= 1.2[1 - e^{-10/2 \times 1}]$

4.5) Comparing the time constant with estimates from manual and simulated plots

The Time constant (T) of a RL circuit uses the formula $T = L/R$, therefore

$$T = 2/10,$$

$$T = 0.2$$



- Simulated time constant

4.6) the time that elapses before the current flowing in the circuit has fallen

a. 100mA

b) 10mA

$$I_L = I_{MAX} [e^{-R/L \times t}]$$

$$I_L / I_{MAX} = e^{-R/L \times t} \quad [\text{use log rules to take out } e]$$

$$\text{Log}(x^y)$$

$$[I_L / I_{MAX}] = \ln [-R/L \times t]$$

$$\ln [I_L / I_{MAX}] = -R/L \times t$$

$$T = L/R \quad \text{so} \quad 1/T = R/L$$

$$\ln [I_L / I_{MAX}] = -t/T$$

$$t = T [\ln [I_L / I_{MAX}]]$$

$$\log (e) = 1$$

$$y = -R/L \times t$$

$$x = e$$

$$T = L / R = 4 / 20 = 0.2$$

$$I_{MAX} = V / R = 12 / 20 = 0.6$$

I_{max} here is wrong. I_{max} is 1.2A

$$5T = 5 \times 0.2 = 1$$

$$t = T [\ln [I_L / I_{MAX}]]$$

$$\text{A) } 0.2 [\ln [0.1 / 0.6]] = 0.358$$

$$\text{B) } 0.2 [\ln [0.01 / 0.6]] = 0.819$$

Method is correct here but I_{max} is wrong value and therefore there is an error in the answer.

RJ assignment 1 investigation into DC transients

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

62/100

PAGE 1

PAGE 2

PAGE 3

Text Comment. Table of contents is good and logical

PAGE 4

Text Comment. All this detail is not required. A simple paragraph on the characteristics of the capacitor under charge and discharge conditions.

PAGE 5

Text Comment. Good points here

Text Comment. All this explanation is not necessary but there are good and correct points made here

Text Comment. Good introduction to the practical

PAGE 6

Text Comment. Good explanations of test methods here. This shows understanding

Text Comment. Good set of charge results

PAGE 7

Text Comment. Graphs are good

Text Comment. All explanation is not necessary

Text Comment. This shows a good characteristic

Text Comment. Good calcs here and good use of table for comparisons

Text Comment. Results look good and a good comparison is shown here

Text Comment. Good results obtained from test

Text Comment. Good graphs showing characteristics for discharge. When using excel sometimes it is best to used text for naming the axis on the graphs.

Text Comment. Good expalnation

Text Comment. Good graphs from ECAD

Text Comment. The graphs are now for current and would be better to have a heading for theses here

Text Comment. Table of values look good

Text Comment. Calcs are good

Text Comment. Good set of results

Text Comment. Calcs are accurate

Text Comment. There is no need for such an extensive explanation, a table of comparison and arguments would be enough. There are good points here all the same.

PAGE 17

Text Comment. Do not use first person terms in any report. Avoid giving a diary of the actions carried out. Assumptions can be made.

Text Comment. This is correct for initial and final currents in the circuit

PAGE 18

Text Comment. Equivalent circuit V_s is not 12v here

PAGE 19

Text Comment. This method is correct

Text Comment. This is the correct equivalent circuit

PAGE 20

Text Comment. This should be explained better. PWM is not necessary here.

PAGE 21

PAGE 22

PAGE 23

PAGE 24

PAGE 25

PAGE 26

Text Comment. This value should be -0.003mA

Text Comment. The significant points of the transient could have been highlighted in the above tasks

Text Comment. Good analysis of the circuit

Text Comment. Good diagram of test setup

PAGE 27

Text Comment. This is good here but what about time constant and transient period. You would have to know these for the ECAD tests.

PAGE 28

Text Comment. These calcs look good

Text Comment. Good table of comparison

PAGE 29

Text Comment. Graphs look good

PAGE 30

PAGE 31

PAGE 32

Text Comment. Good analysis

Text Comment. This is correct here

PAGE 33

Text Comment. I_{max} here is wrong. I_{max} is 1.2A

Text Comment. Method is correct here but I_{max} is wrong value and therefore there is an error in the answer.

GRADING FORM: CSG-RUBIC

MASON MORGAN

0

RESEARCH-INFORMED LITERATURE



N/a

KNOWLEDGE AND UNDERSTANDING



Introduction included many points and explanations but not all was necessary. However a good understanding was demonstrated. 6/10 results and discussion were extensive and not all were good points. Some characteristic points were missed also. There was an understanding in the explanations. 9/15

15/25

ANALYSIS



The testing was carried out using good methods and this is documented in report. There were errors in calculations in task 4 and I_{max} was the wrong value. The comparison tables were good and the readings and calcs all tied up. 20.5/30 Conclusions were given in all tasks but there was far too much information than was necessary and no overall conclusion. 5.5/10

25/40

PRACTICAL APPLICATION AND DEP.



Circuit testing was carried out using effective methods and explained in full. the results were obtained and comparisons made using tables. 10/15

16/25

The quality of the test results was good and included explanations. Methods of testing used showed a good understanding. 6/10

SKILLS FOR PROFESSIONAL PRAC.



Quality of the report is good but no need for as much explanation.

6/10