

Assignment - Electronic Principles

by Rhys Davies

FILE	16479_RHYS_DAVIES_ASSIGNMENT_-_ELECTRONIC_PRINCIPLES_139105_1391633974.PDF (3.5M)		
TIME SUBMITTED	28-JAN-2019 06:38PM (UTC+0000)	WORD COUNT	4542
SUBMISSION ID	99939406	CHARACTER COUNT	20995

HNC Electrical And Electronic Engineering
PSDE4001/SGEE4000 - Electronic Principles

Assignment 1 - Investigation into DC
Transients

Author: Rhys Davies (1809809)

28th January 2019

Table Of Contents:

	Page:
Introduction:	3
Task 1 - Transient Behaviour For Charging of a Capacitor	3
1.1 Practical Results:	4
1.2: Voltage	6
1.3 Simulated Results:	6
1.4 Calculated Results:	7
1.5 Current:	8
1.6 Simulated Results:	8
1.7 Calculated Results:	8
Task 2 - Transient Behaviour For Discharging of a Capacitor	10
2.1 Practical Results:	10
2.2 Voltage:	11
2.3 Simulated Results:	11
2.4 Calculated Results:	11
2.5 Current:	13
2.6 Simulated Results:	13
2.7 Calculated Results:	13
Task 3 - Transient Behaviour For a Complex circuit	15
3.1 Voltage:	17
3.2 Simulated Results:	17
3.3 Calculated Results:	17
3.4 Current:	19
3.5 Simulated Results:	19
3.6 Calculated Results:	19
3.7 Transient Behaviour For Discharging of a Complex CCT	21
3.8 Voltage:	21
3.9 Simulated Results:	21
3.10 Calculated Results:	21
3.11 Current:	23
3.12 Simulated Results:	23
3.13 Calculated Results:	23
Task 4 - Transient Behaviour of an Inductive circuit	25
4.1 Calculated Results:	26
Conclusion:	30

Table of contents is good but needs a list of figures to complement the contents

Introduction:

This assignment looks into different types of purely R/C (resistor/capacitor) circuits and purely R/L (Resistor/Inductor) circuits and the relationship between components and the effects it has on the circuit 'transient time' (the time it takes for the circuit to reach steady state) after power up or power disconnection.

Using computer based simulation 'Multi-Sim', the circuits can be built and Voltage/Current transients can be analysed which can give more accurate and detailed results.

We will also mathematically calculate and, where possible, practically setup and carry out Voltage/Current measurements and compare/contrast them to see if simulation and practical tests are accurate and reliable.

We will also use different equations to simplify complex circuits so that the Transient equation can be applied simply and then it's result can be verified via simulation. *Good intro*

Task 1 - Transient Behaviour For Charging of a Capacitor

The circuit designed and used to demonstrate the transient behaviour is shown below:

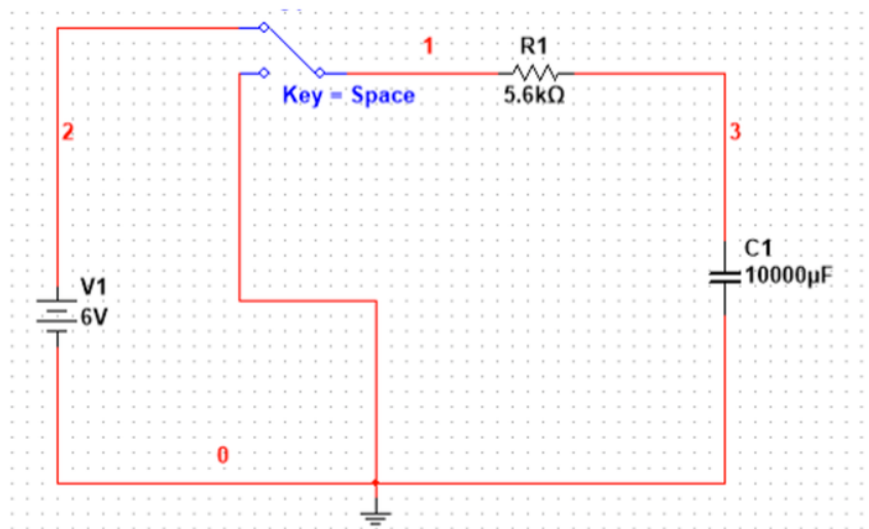


FIG 1: SIMPLE R/C CIRCUIT

Reason for component values:

As the transient time is a result of the values of resistance and capacitance in the circuit, using the formula:

$$T = R \times C$$

(where T equals the transient time, R represents 'Resistance' and C represents 'Capacitance')

$$T = R \times C = 5600 \times 10 \times 10^{-3} = \mathbf{56 \text{ SECONDS}}$$

the value of resistance and capacitance give a 56 SECOND transient time (T), which results in an overall transient period (5T) of 280 SECONDS. This period is suitable to take voltage and current readings in real time and see a change between readings to be plotted.

*Parameters
for testing
have been
identified*



FIG 2: PRACTICAL R/C CIRCUIT SETUP

Good clear image of setup

1.1 Practical Results:

The circuit was set up using a breadboard, and 2 multimeters (measuring Capacitor Voltage and Circuit current separately) were implemented and the changes were measured and tabulated as shown below:

Practical Results - Voltage/Current During Charge Cycle

Time	Volts	Current
20	1.77	0.725
40	3.01	0.514
60	3.82	0.361
80	4.43	0.260
100	4.87	0.186
120	5.16	0.133
140	5.37	0.098
160	5.53	0.069
180	5.64	0.057
200	5.72	0.38
220	5.77	0.028
240	5.81	0.021
260	5.84	0.016
280	5.86	0.013

Values are good

FIG 3: PRACTICAL RESULTS OF R/C CIRCUIT - CHARGE VOLTAGE & CURRENT

Assignment - Electronic Principles

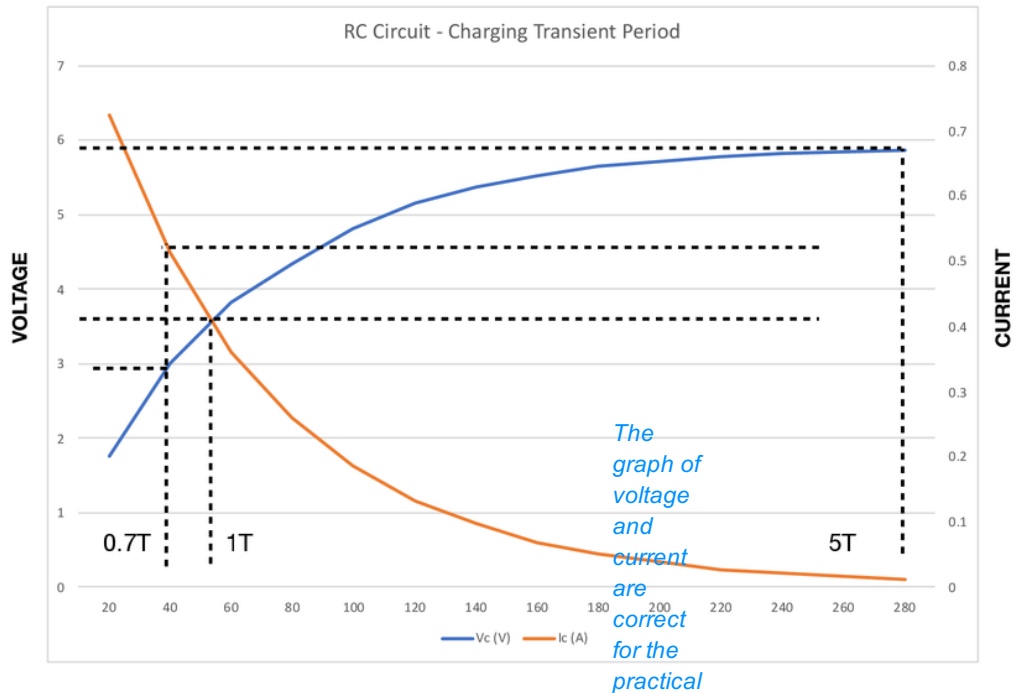


FIG 4: GRAPHED PRACTICAL RESULTS OF R/C CIRCUIT - CHARGE

The graph above shows the capacitor voltage rise from 0V to around 6V (Supply voltage) within the calculated time of 280 seconds and is known as the 'transient period'. This period is where the voltage is changing most rapidly as the components in the circuit are reacting to the supplied voltage. After this time, the voltage increase is negligible and the circuit is considered to be in a 'steady state'. Cursors were included to show the $0.7T$, $1T$ and $5T$ times to indicate the results of voltage (on the left vertical scale) and current (on the right vertical scale).

*Good graph showing significant points
but why are these significant points*

1.2: Voltage

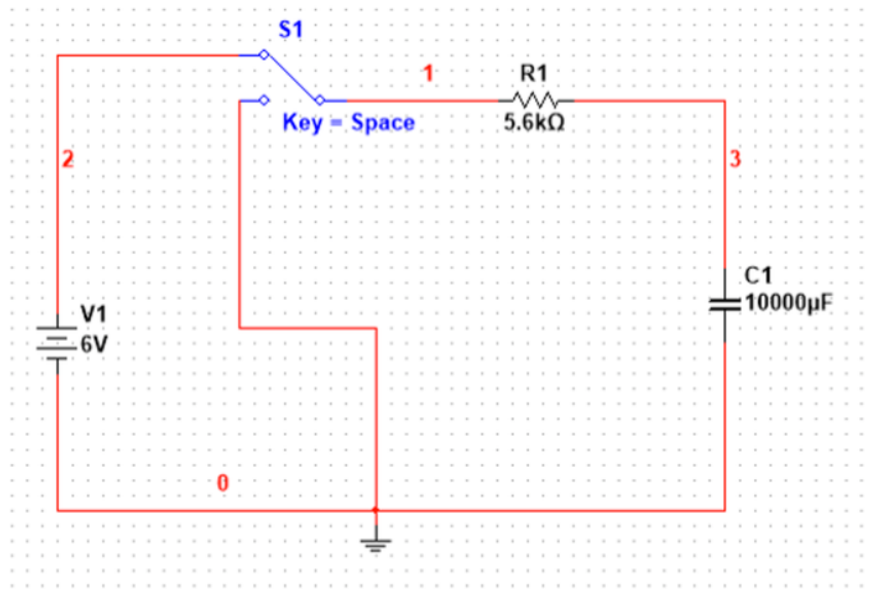


FIG 5: SIMPLE R/C CIRCUIT

1.3 Simulated Results:

Using the program 'MultiSim', we can build the exact same circuit and using the simulation feature, graphs of charge voltage and current can be obtained and compared with the formed graphs from the practical results.

Multisim graph:

With the simulated results, three time points were chosen and added to compare with practical results.

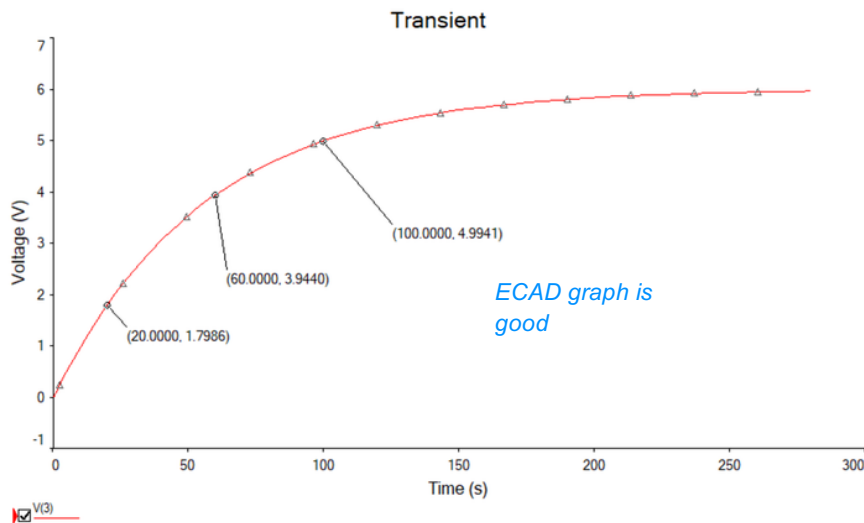


FIG 6: SIMPLE R/C CIRCUIT - CHARGE VOLTAGE

1.4 Calculated Results:

Using the formula:

$$V_c = V_{MAX} (1 - e^{-(t/T)})$$

Where t = instantaneous time (sec)

T = Transient Period (sec)

T is identified as the time constant which is not the transient period. $T = R \times C$ and $5T$ is the transient period

we now can calculate mathematically, the Voltage at specific intervals of the transient period.

Time 1: (20 seconds)

$$\begin{aligned} V_c &= V_{MAX} (1 - e^{-(t/T)}) \\ &= 6 (1 - e^{-(20/56)}) \\ &= 6 (0.3003) \\ &= 1.802V \end{aligned}$$

Time 2: (60 seconds)

$$\begin{aligned} V_c &= V_{MAX} (1 - e^{-(t/T)}) \\ &= 6 (1 - e^{-(60/56)}) \\ &= 6 (0.6575) \\ &= 3.945V \end{aligned}$$

Calcs are correct

Time 3: (100 seconds)

$$\begin{aligned} V_c &= V_{MAX} (1 - e^{-(t/T)}) \\ &= 6 (1 - e^{-(100/56)}) \\ &= 6 (0.8323) \\ &= 4.993V \end{aligned}$$

Results Comparison - Voltage During Charge Cycle

Time	Practical (V)	Simulated (V)	Calculated (V)
20	1.77	1.7986	1.802
60	3.82	3.944	3.945
100	4.97	4.994	4.993

FIG 7: COMPARISON TABLE OF CHARGE VOLTAGE

Good table of values with good comparisons

1.5 Current:

1.6 Simulated Results:

Using the same circuit in 'Multi-Sim', we can now simulate charge current in the circuit using the 20, 60 and 100 second measurements for calculation and comparison:

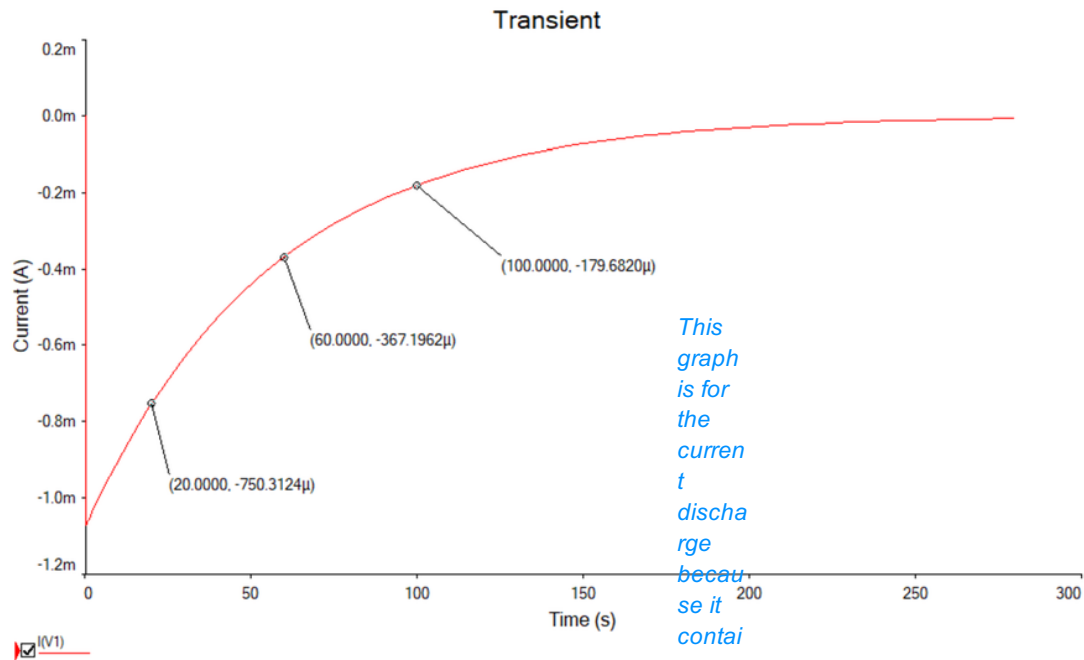


FIG 8: SIMPLE R/C CIRCUIT - CHARGE CURRENT

1.7 Calculated Results:

Using the formula:

$$I_c = I_{MAX} (e^{-(t/T)})$$

Where $I_{MAX} = V_s/R$ (in Ohms) = 6/5600

t = instantaneous time (sec)

T = Transient Period (sec)

I_{max} is identified

we can calculate mathematically, the Voltage and Current at specific intervals of the transient period.

Time 1: (20 seconds)

$$\begin{aligned} I_c &= I_{MAX} (e^{-(t/T)}) \\ &= 6/5600 (e^{-(20/56)}) \\ &= 1.071 \times 10^{-3} (0.699) \\ &= 7.4965 \times 10^{-4} \text{ A} \\ &= -749.65 \mu\text{A} \end{aligned}$$

Time 2: (60 seconds)

Assignment - Electronic Principles

$$\begin{aligned}I_c &= I_{MAX} (e^{-(t/T)}) \\&= 6/5600 (e^{-(60/56)}) \\&= 1.071 \times 10^{-3} (0.343) \\&= 3.6698 \times 10^{-4} \text{ A} \\&= -366.98 \mu\text{A}\end{aligned}$$

Calcs are correct but should be positive values

Time 3: (100 seconds)

$$\begin{aligned}I_c &= I_{MAX} (e^{-(t/T)}) \\&= 6/5600 (e^{-(100/56)}) \\&= 1.071 \times 10^{-3} (0.168) \\&= 1.7965 \times 10^{-4} \text{ A} \\&= -179.654 \mu\text{A}\end{aligned}$$

Results Comparison - Current During Charge Cycle

Time	Practical (uA)	Simulated (uA)	Calculated (uA)
20	-725	-750.312	-749.65
60	-361	-367.196	-366.98
100	-186	-179.682	-179.654

FIG 9: COMPARISON TABLE OF CHARGE CURRENT

The differences in the charge voltage and current values between the simulated and calculated results are minimal, with the difference down to the rounding of fractions included in the calculated equations.

The practical results however, are slightly off, which could be attributed to component values tolerances in the built circuit, extra resistances and inductances from other components such as conductors, the multimeters and the power source. Also, there would be the slight time differences in measurements from applying the power source to taking readings.

The values for the charge current should be positive values going toward zero

Task 2 - Transient Behaviour For Discharging of a Capacitor

Repeating the same circuit analysis as demonstrated in Task 1, we will now perform the same measurements during the discharge transient of the capacitor. The Transient period remains the same (56 seconds) as the component values have not changed.

2.1 Practical Results:

Practical Results - Voltage/Current During Discharge Cycle

Time	Volts	Current
20	4.17	-0.750
40	3.00	-0.513
60	2.12	-0.369
80	1.49	-0.256
100	1.06	-0.184
120	0.77	-0.131
140	0.54	-0.094
160	0.39	-0.068
180	0.28	-0.048
200	0.2	-0.035
220	0.15	-0.025
240	0.1	-0.018
260	0.08	-0.014
280	0.06	-0.01

Good set of results and the negative values are correct here

FIG 10: PRACTICAL RESULTS OF R/C CIRCUIT - DISCHARGE VOLTAGE & CURRENT

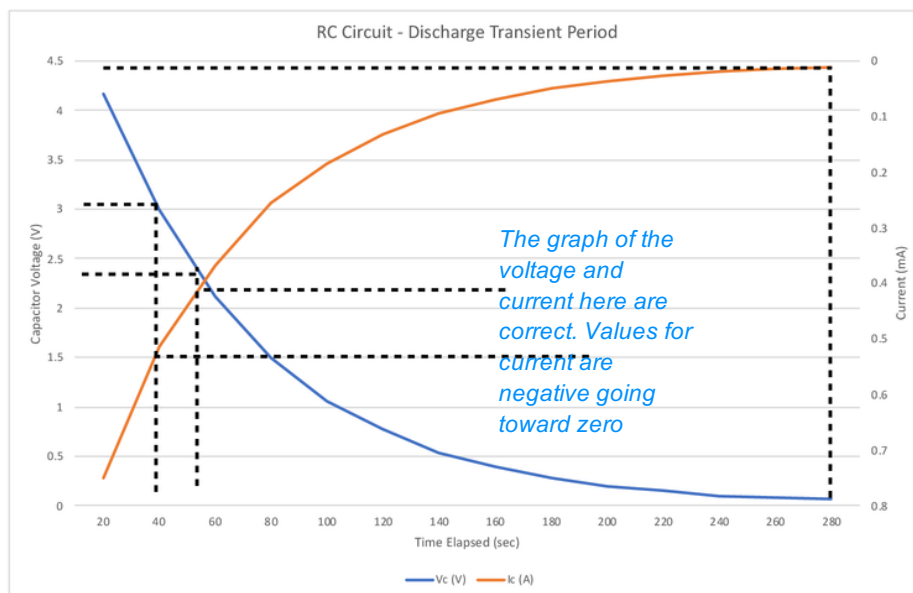


FIG 11: GRAPHED RESULTS OF R/C CIRCUIT - DISCHARGE VOLTAGE & CURRENT

2.2 Voltage:

2.3 Simulated Results:

Multisim graph:

With the simulated results, three time points were chosen and added to compare with practical results.

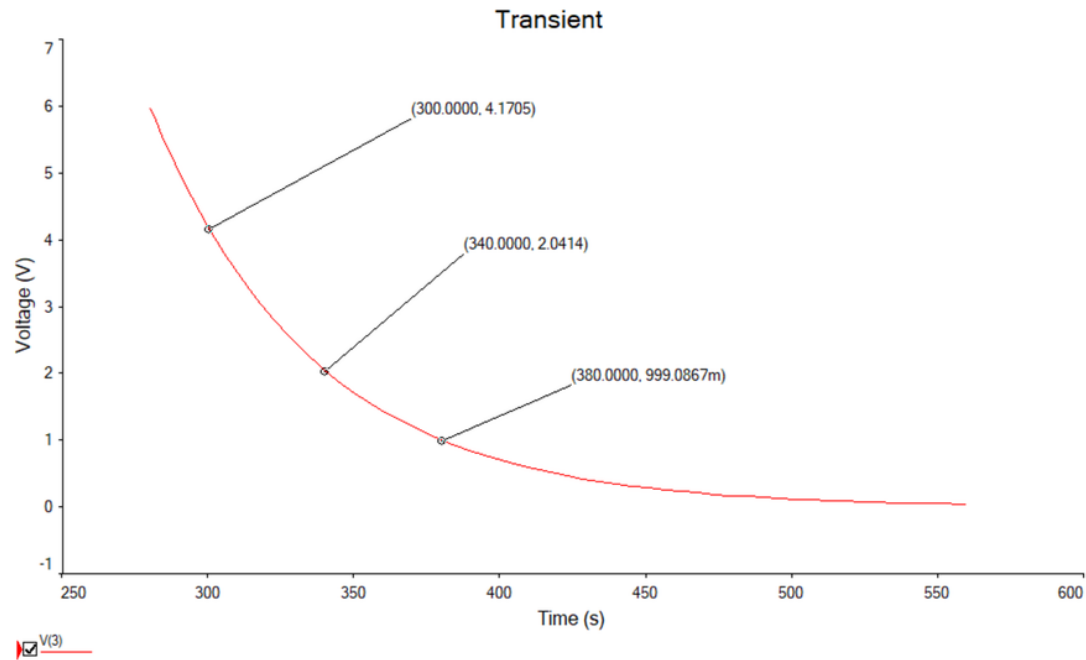


FIG 12: SIMULATED GRAPH OF R/C CIRCUIT - DISCHARGE VOLTAGE

2.4 Calculated Results:

Using the formula:

$$V_C = V_{MAX} (e^{-t/T})$$

Where t = instantaneous time (sec)

T = Transient Period (sec)

we can calculate mathematically, the Voltage and Current at specific intervals of the transient period.

Time 1: (20 seconds)

$$\begin{aligned} V_C &= V_{MAX} (e^{-t/T}) \\ &= 6 (e^{-20/56}) \\ &= 6 (0.697) \\ &= 4.198V \end{aligned}$$

Assignment - Electronic Principles

Time 2: (60 seconds)

$$\begin{aligned}V_C &= V_{MAX} (1 - e^{-(t/T)}) \\&= 6 (e^{-(60/56)}) \\&= 6 (0.3425) \\&= 2.055V\end{aligned}$$

Time 3: (100 seconds)

$$\begin{aligned}V_C &= V_{MAX} (1 - e^{-(t/T)}) \\&= 6 (e^{-(100/56)}) \\&= 6 (0.167) \\&= 1.006V\end{aligned}$$

Results Comparison - Voltage During Discharge Cycle

Time	Practical (V)	Simulated (V)	Calculated (V)
20	4.17	4.1705	4.198
60	2.12	2.0414	2.055
100	1.06	0.9991	1.006

FIG 13: COMPARISON TABLE OF R/C CIRCUIT - DISCHARGE VOLTAGE

*Comparison of
values is good
and calcs match
the prac and
ECAD*

2.5 Current:

2.6 Simulated Results:

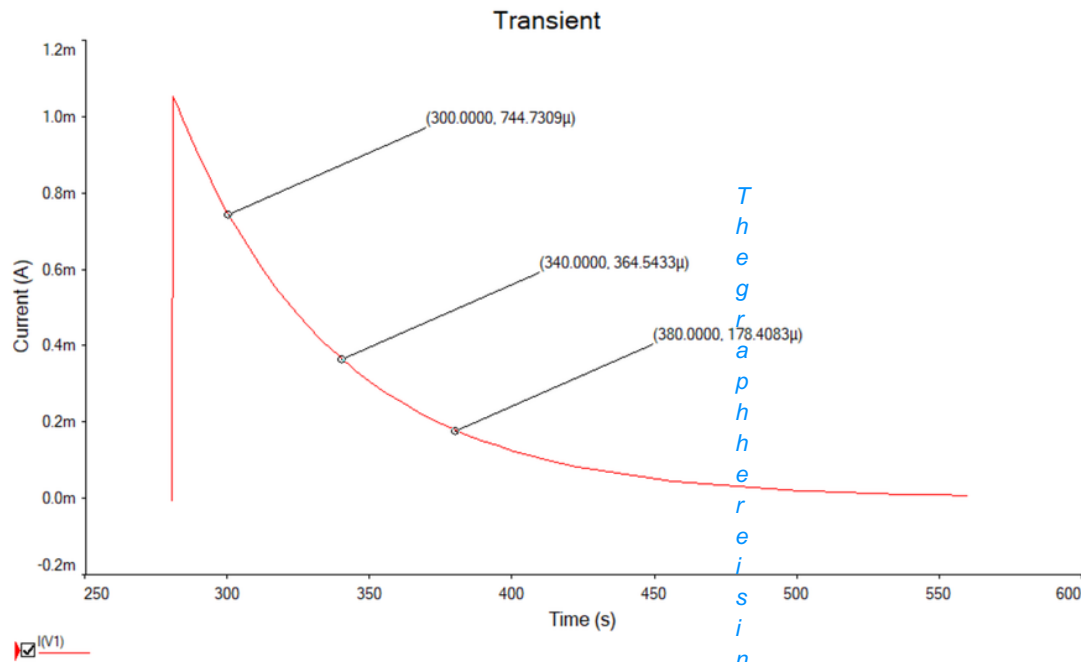


FIG 14: SIMULATED GRAPH OF R/C CIRCUIT - DISCHARGE CURRENT

2.7 Calculated Results:

Using the formula:

$$I_c = -I_{MAX} (e^{-(t/T)})$$

Where $I_{MAX} = V_s/R$ (in Ohms) = $6/5600$

t = instantaneous time (sec)

T = Transient Period (sec)

we can calculate mathematically, the Voltage and Current at specific intervals of the transient period.

Time 1: (20 seconds)

$$\begin{aligned} I_c &= I_{MAX} (e^{-(t/T)}) \\ &= -(6/5600) (e^{-(20/56)}) \\ &= 1.071 \times 10^{-3} (0.699) \\ &= 7.4965 \times 10^{-4} \text{ A} \\ &= -749.65 \mu\text{A} \end{aligned}$$

Time 2: (60 seconds)

$$\begin{aligned} I_c &= I_{MAX} (e^{-(t/T)}) \\ &= -(6/5600) (e^{-(60/56)}) \end{aligned}$$

Calculations are actually correct despite the graph

Assignment - Electronic Principles

$$= 1.071 \times 10^{-3} (0.343)$$

$$= 3.6698 \times 10^{-4} \text{ A}$$

$$= -366.98 \mu\text{A}$$

Time 3: (100 seconds)

$$I_c = I_{\text{MAX}} (e^{-(t/T)})$$

$$= -(6/5600) (e^{-(100/56)})$$

$$= 1.071 \times 10^{-3} (0.168)$$

$$= 1.7965 \times 10^{-4} \text{ A}$$

$$= -179.654 \mu\text{A}$$

The comparison table of values are correct because the negative values are going positive with time t

Results Comparison - Current During Discharge Cycle

Time	Practical (uA)	Simulated (uA)	Calculated (uA)
20	-725	-744.731	-749.65
60	-361	-364.543	-366.98
100	-186	178.408	-179.654

FIG 15: RESULTS TABLE OF R/C CIRCUIT - DISCHARGE VOLTAGE

Team Comments:

The multimeters were setup with auto ranging disabled so with Voltage readings in particular, the accuracy of the figures recorded were only to two decimal places.

Also, with the multimeters changing so rapidly at the beginning due to quick changes in voltage/current during the charge/discharge transients, accurate readings exactly on the numerous time stamps could result in 'notchy' and 'rough' graph plots.

We did decide as a group to increase our reading frequency to 10 seconds, although the 'odd' time results weren't tabulated, to increase the chances of an accurate graph if one was missed and increase the 'smoothness' of the graph plot.

Good conclusion for the result differences

Task 3 - Transient Behaviour For a Complex circuit

This task looks into the behaviour of a complex RC circuit where there is an added resistance in parallel to the capacitor.

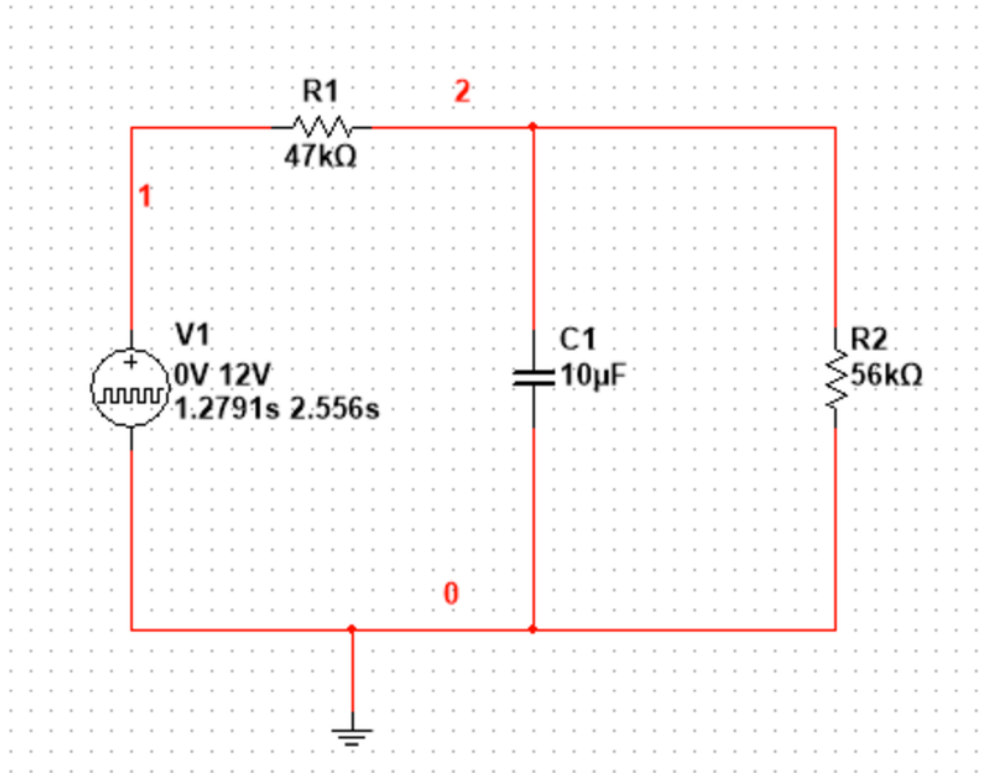


FIG 16: COMPLEX R/C CIRCUIT

Before we can calculate the Transient period time (T), we need to reduce the circuit to a simplified version where we have an overall resistance.

During the initial 12V pulse, the capacitor will act as a SHORT CIRCUIT and effectively, bypass R2, therefore, during power up:

$$\begin{aligned}\text{Initial } I_{\text{MAX}} &= V/R_1 \\ &= 12/47000 \\ &= 2.55 \times 10^{-3} \text{ A} \\ &= 255 \mu\text{A}\end{aligned}$$

Imax is identified

As the capacitor, becomes saturated, current will then also flow through R2 and the current will be:

$$\begin{aligned}\text{Final } I_{\text{MAX}} &= V/R_1 + R_2 \\ &= 12/47000 + 56000 \\ &= 1.16 \times 10^{-3} \text{ A} \\ &= 116 \mu\text{A}\end{aligned}$$

Final value for Imax is correct

Assignment - Electronic Principles

Equivalent Circuit:

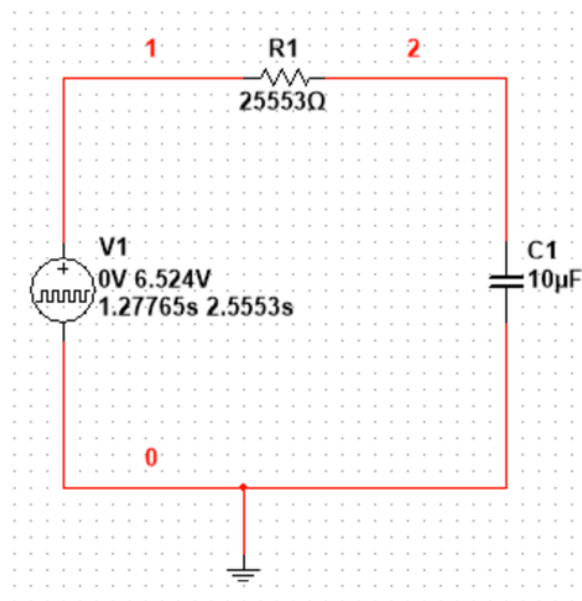
To calculate the equivalent circuit, we need to remove the power supply and capacitor, and then calculate the resulting resistance with the two remaining resistances:

$$\frac{R_1 \times R_2}{R_1 + R_2} = \frac{47\text{k}\Omega \times 56\text{k}\Omega}{47\text{k}\Omega + 56\text{k}\Omega} = \frac{2632\text{k}\Omega}{103\text{k}\Omega} = \mathbf{25.553\text{k}\Omega}$$

Lastly we need to determine the Voltage that exists across the capacitor by using the voltage divider rule.

$$V_c = V_s \times R_2 / (R_1 + R_2) = 12 \times 56 / (47 + 56) = \mathbf{6.524V}$$

Using the new equivalent circuit values, we can now build the equivalent circuit ready for analysis and determine the transient period (T) using the new figures:



Equivalent circuit is correct with parameters set for testing

FIG 17: COMPLEX R/C CIRCUIT SIMPLIFIED

$$T = R \times C$$

(where T equals the transient time, R represents 'Equivalent Resistance' and C represents 'Capacitance')

$$T = R \times C = 25553 \times 10 \times 10^{-6} = 0.25553 \text{ SECONDS}$$

This gives a 0.25553 SECOND transient time (T), which results in an overall transient period (5T) of 1.27765 SECONDS. This transient period is not suitable to take voltage and current readings physically as it would be impossible to take multiple readings at multiple times, tabulate and graph them. But due to the use of an electronic simulator program (Multisim), we have simulated results available to use.

Good explanation here and important parameters have been identified

3.1 Voltage:

3.2 Simulated Results:

Using the program 'MultiSim', we can build the exact same circuit and using the simulation feature, graphs of charge voltage and current can be obtained and compared with the formed graphs from the practical results.

Multisim graph:

With the simulated results, we've added three set points to compare with practical results.

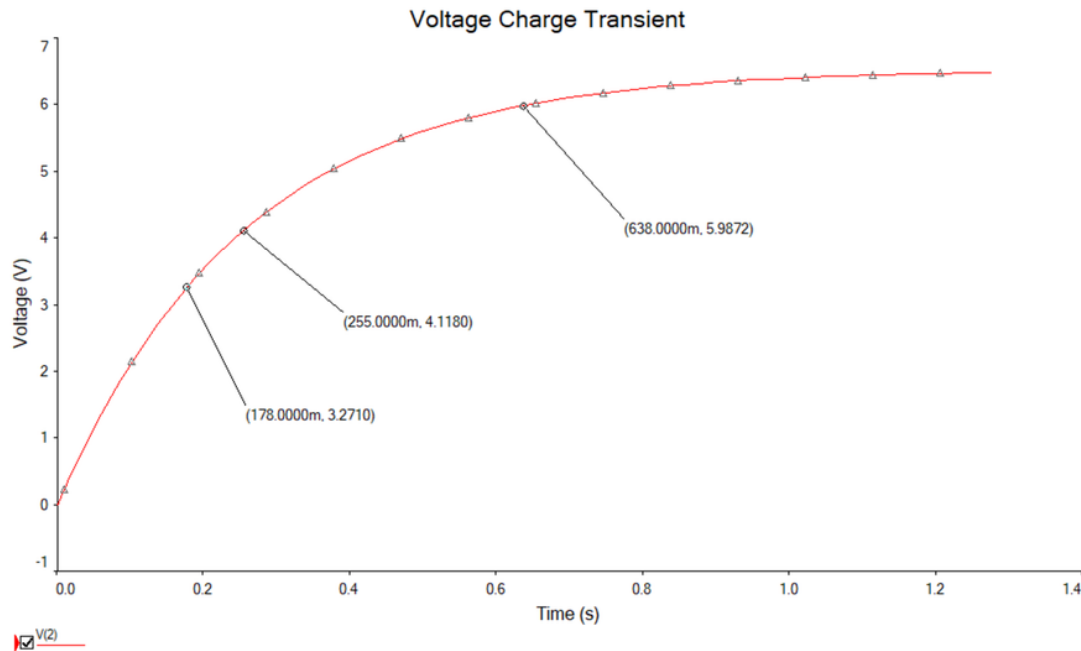


FIG 18: SIMULATED GRAPH OF COMPLEX R/C CIRCUIT - CHARGE VOLTAGE

3.3 Calculated Results:

Using the formula:

$$V_C = V_{MAX} (1 - e^{-t/T})$$

Where t = instantaneous time (sec)

T = Transient Period (sec)

T is Time constant $5T$ is transient period

we can calculate mathematically, the Voltage and Current at specific intervals of the transient period.

Time 1 (0.7t): (0.1788 seconds)

$$\begin{aligned} V_C &= V_{MAX} (1 - e^{-t/T}) \\ &= 6.524 (1 - e^{-(0.1788/0.25553)}) \\ &= 6.524 (0.5033) \\ &= 3.284V \end{aligned}$$

Since 0.7T is chosen then this should be half of V_s

Assignment - Electronic Principles

Time 2 (1t): (0.25553 seconds)

$$\begin{aligned} V_C &= V_{MAX} (1 - e^{-t/T}) \\ &= 6.524 (1 - e^{-(0.25553/0.25553)}) \\ &= 6.524 (0.6321) \\ &= 4.124V \end{aligned}$$

Calculations are correct and match the graph values

Time 3 (2.5t): (0.6388 seconds)

$$\begin{aligned} V_C &= V_{MAX} (1 - e^{-t/T}) \\ &= 6.524 (1 - e^{-(0.6388/0.25553)}) \\ &= 6.524 (0.9179) \\ &= 5.988V \end{aligned}$$

Results Comparison - Voltage During Charge Cycle (Complex CCT)

Time (sec)	Simulated (V)	Calculated (V)
0.1788	3.284	3.271
0.25553	4.124	4.118
0.6388	5.988	5.9872

FIG 19: COMPARISON TABLE OF COMPLEX R/C CIRCUIT - CHARGE VOLTAGE

comparisons

3.4 Current:

3.5 Simulated Results:

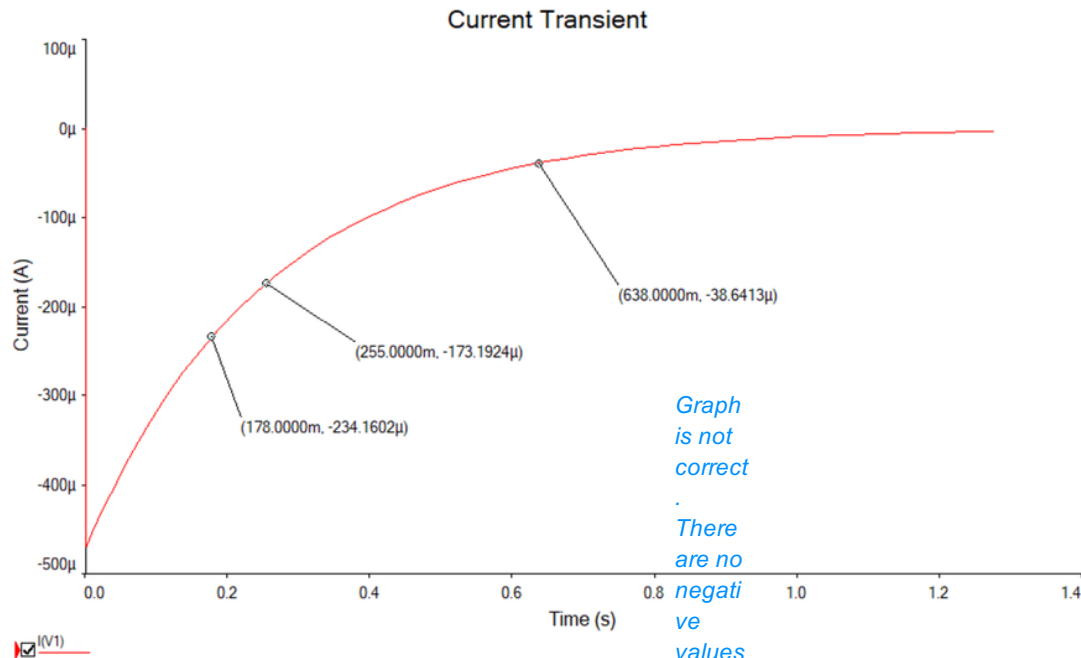


FIG 20: SIMULATED GRAPH OF COMPLEX R/C CIRCUIT CHARGE CURRENT

3.6 Calculated Results:

Using the formula:

$$I_c = I_{MAX} (e^{-(t/T)})$$

Where $I_{MAX} = V_s/R$ (in Ohms) = $12/25553$

t = instantaneous time (sec)

T = Transient Period (sec)

we can calculate mathematically, the Voltage and Current at specific intervals of the transient period.

Time 1 (0.7t): (0.1788 seconds)

$$\begin{aligned} I_c &= I_{MAX} (e^{-(t/T)}) \\ &= 12/25553 (e^{-(0.1788/0.25553)}) \\ &= 4.696 \times 10^{-4} (0.4967) \\ &= 2.3327 \times 10^{-4} \text{ A} \\ &= -233.26 \mu\text{A} \end{aligned}$$

Time 2 (1t): (0.25553 seconds)

Assignment - Electronic Principles

$$\begin{aligned}I_c &= I_{MAX} (e^{-t/T}) \\&= 12/25553 (e^{-\{0.25553/0.25553\}}) \\&= 4.696 \times 10^{-4} (0.3679) \\&= 1.7276 \times 10^{-5} \text{ A} \\&= -172.76 \mu\text{A}\end{aligned}$$

Time 3 (2.5t): (0.6388 seconds)

Calcs are the correct values but should be positive

$$\begin{aligned}I_c &= I_{MAX} (e^{-t/T}) \\&= 12/25553 (e^{-\{0.6388/0.25553\}}) \\&= 4.696 \times 10^{-4} (0.082) \\&= 3.8552 \times 10^{-5} \text{ A} \\&= -38.552 \mu\text{A}\end{aligned}$$

Results Comparison - Current During Charge Cycle (Complex CCT)

Time	Simulated (uA)	Calculated (uA)
0.1788	-234.1602	-233.26
0.25553	-173.1924	-172.76
0.6388	-38.6413	-38.552

FIG 21: COMPARISON TABLE OF COMPLEX R/C CIRCUIT - CHARGE CURRENT

Comparison of number values can be taken from the table but there are no negative values during charge

3.7 Transient Behaviour For Discharging of a Complex CCT

3.8 Voltage:

3.9 Simulated Results:

Multisim graph:

With the simulated results, we've added three set points to compare with practical results.

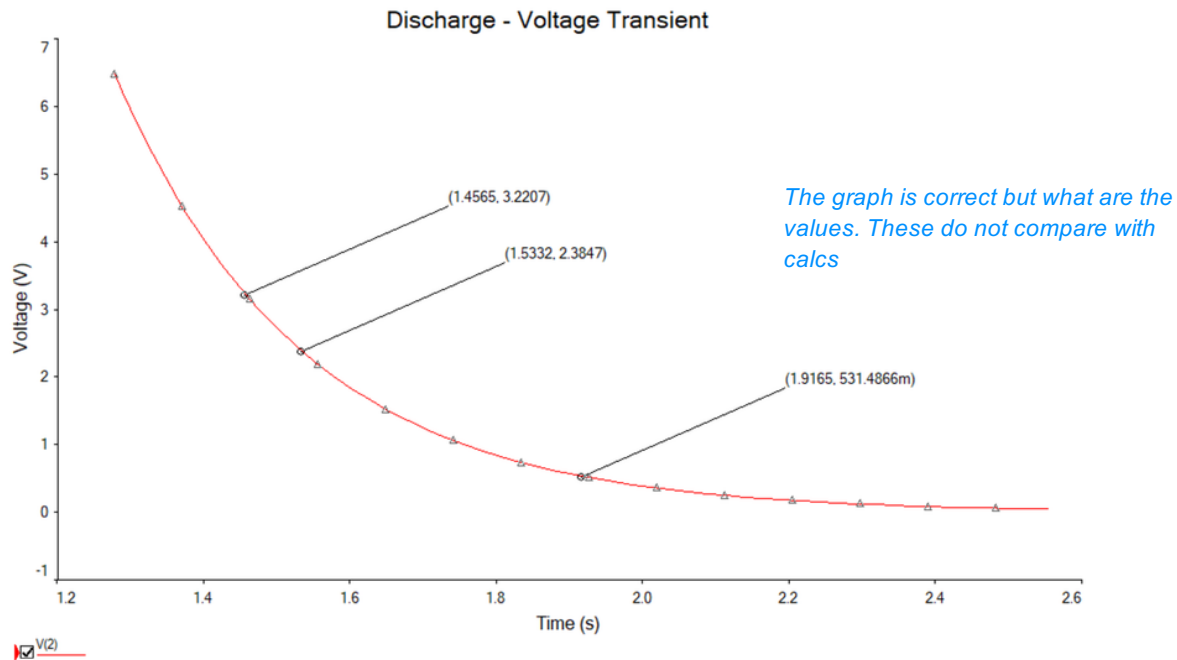


FIG 22: SIMULATED GRAPH OF COMPLEX R/C CIRCUIT - DISCHARGE VOLTAGE

3.10 Calculated Results:

Using the formula:

$$V_c = V_{MAX} (e^{-t/T})$$

Where t = instantaneous time (sec)

T = Transient Period (sec)

we can calculate mathematically, the Voltage and Current at specific intervals of the transient period.

Time 1 (0.7t): (0.1788 seconds)

$$\begin{aligned} V_c &= V_{MAX} (e^{-t/T}) \\ &= 6.524 (e^{-0.1788/0.25553}) \\ &= 6.524 (0.697) \\ &= 4.198V \end{aligned}$$

Calc is incorrect here

Assignment - Electronic Principles

Time 2 (1t): (0.25553 seconds)

$$\begin{aligned}V_C &= V_{MAX} (1 - e^{-t/T}) \\&= 6.524 (e^{-0.25553/0.25553}) \\&= 6.524 (0.3425) \\&= 2.055V\end{aligned}$$

This calc is incorrect

Time 3 (2.5t): (0.6388 seconds)

$$\begin{aligned}V_C &= V_{MAX} (1 - e^{-t/T}) \\&= 6 (e^{-0.6388/0.25553}) \\&= 6.524 (0.167) \\&= 1.006V\end{aligned}$$

Calc value is incorrect

Results Comparison - Voltage During Discharge Cycle (Complex CCT)

Time	Simulated (V)	Calculated (V)
0.1788 (0.7T)	3.2207	3.2406
0.25553 (1T)	2.3847	2.4
0.6388 (2.5T)	0.531	0.535

FIG 23: COMPARISON TABLE OF COMPLEX R/C CIRCUIT - DISCHARGE VOLTAGE

*The values in the table are not the
calculated values*

3.11 Current:

3.12 Simulated Results:

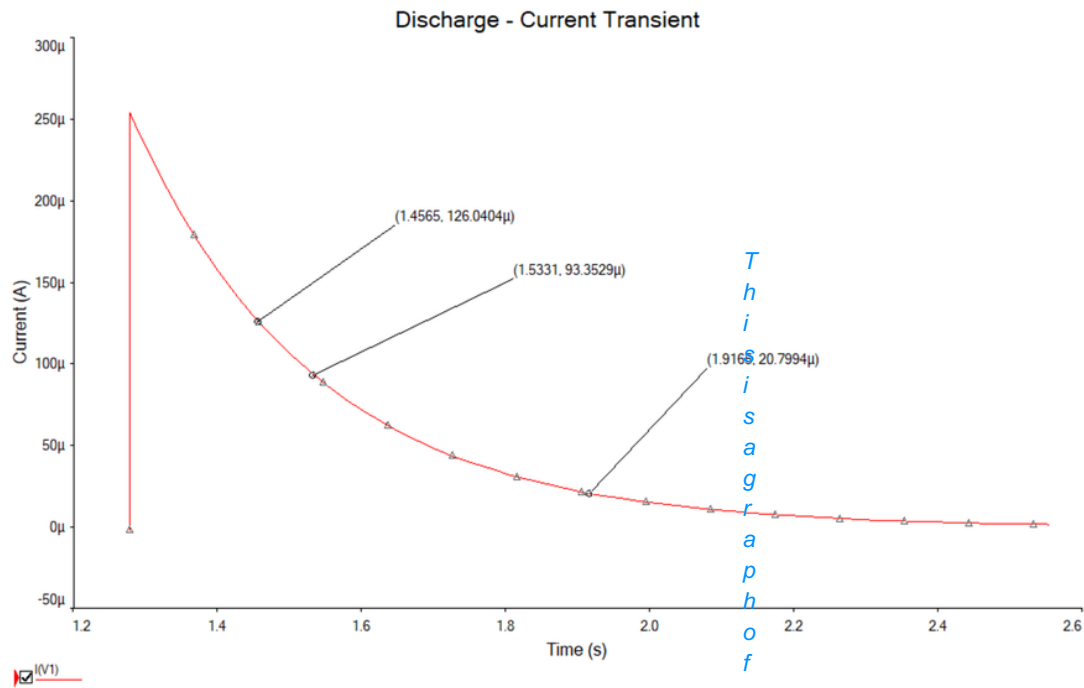


FIG 24: SIMULATED GRAPH OF COMPLEX R/C CIRCUIT - DISCHARGE CURRENT

3.13 Calculated Results:

Using the formula:

$$I_c = -I_{MAX} (e^{-(t/T)})$$

Where $I_{MAX} = V_s/R$ (in Ohms)

t = instantaneous time (sec)

T = Transient Period (sec)

we can calculate mathematically, the Voltage and Current at specific intervals of the transient period.

Time 1 (0.7t): (0.1788 seconds)

$$\begin{aligned} I_c &= -I_{MAX} (e^{-(t/T)}) \\ &= -(6.54/25553) (e^{-(0.1788/0.25553)}) \\ &= -1.071 \times 10^{-3} (0.699) \\ &= -1.2713 \times 10^{-4} \text{ A} \\ &= -127.13 \mu\text{A} \end{aligned}$$

Time 2 (1t): (0.25553 seconds)

$$\begin{aligned} I_c &= I_{MAX} (e^{-(t/T)}) \\ &= -(6.54/25553) (e^{-(0.25553/0.25553)}) \end{aligned}$$

Assignment - Electronic Principles

$$= 1.071 \times 10^{-3} (0.343)$$

$$= -9.4155 \times 10^{-5} \text{ A}$$

$$= -94.15 \mu\text{A}$$

Time 3 (2.5t): (0.6388 seconds)

$$I_c = I_{\text{MAX}} (e^{-t/T})$$

$$= -(6.54/25553) (e^{-0.6388/0.25553})$$

$$= -1.071 \times 10^{-3} (0.168)$$

$$= -2.101 \times 10^{-5} \text{ A}$$

$$= -21.01 \mu\text{A}$$

The number values of calcs are correct but graph is showing positive values

Results Comparison - Current During Discharge Cycle (Complex CCT)

Time	Simulated (uA)	Calculated (uA)
0.1788 (0.7T)	-126.04	-127.13
0.25553 (1T)	-93.353	-94.15
0.6388 (2.5T)	-20.799	-21.01

The table of comparisons is logical and correct if the graph can be ignored

FIG 25: SIMULATED GRAPH OF COMPLEX R/C CIRCUIT - DISCHARGE CURRENT

v) Initial and Final Current:

Initial:

$$I_{\text{MAX}} = V_s/R \text{ (in Ohms)}$$

$$= 12/47000$$

$$= 255 \mu\text{A}$$

Final:

$$I_{\text{MAX}} = V_s/R \text{ (in Ohms)}$$

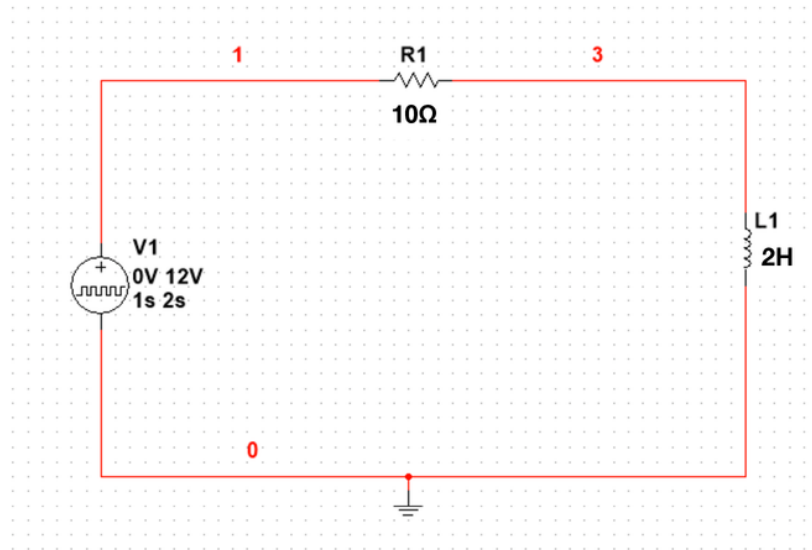
$$= 12/103000$$

$$= 116.5 \mu\text{A}$$

The initial and final values of current are identified

Task 4 - Transient Behaviour of an Inductive circuit

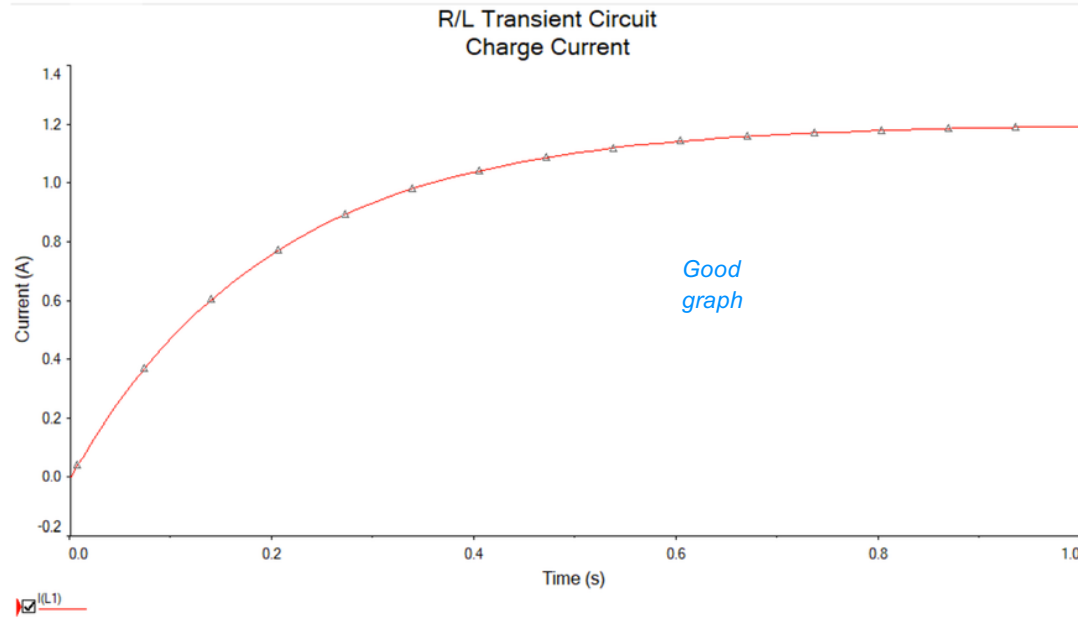
Using the circuit shown below, current growth was captured during the first second after full voltage was applied.



Good identification of test setup with Vs pulse input

FIG 26: SIMPLE R/L CIRCUIT

Using Multisim, the growth of current was captured and shown on the below graph.



Good graph

FIG 27: SIMULATED GRAPH OF R/L CIRCUIT - CHARGE CURRENT FOR 1 SECOND

Assignment - Electronic Principles

1. Carry out calculations (using the approximate method of calculation) and manually plot this current. Compare with simulation and comment.

4.1 Calculated Results:

Using the formula:

$$I_L = I_{MAX} (1 - e^{-(R/L)t})$$

Where t = instantaneous time (sec)

Time 1 (0.7T): (0.14 seconds)

$$\begin{aligned} I_L &= I_{MAX} (1 - e^{-(R/L)t}) \\ &= 1.2 (1 - e^{-(10/2) 0.14}) \\ &= 1.2 (0.5034) \\ &= 0.604A \end{aligned}$$

Time 2 (1.2T): (0.24 seconds)

$$\begin{aligned} I_L &= I_{MAX} (1 - e^{-(R/L)t}) \\ &= 1.2 (1 - e^{-(10/2) 0.24}) \\ &= 1.2 (0.6988) \\ &= 0.8386A \end{aligned}$$

Time 3 (2T): (0.4 seconds)

$$\begin{aligned} I_L &= I_{MAX} (1 - e^{-(R/L)t}) \\ &= 1.2 (1 - e^{-(10/2) 0.4}) \\ &= 1.2 (0.8646) \\ &= 1.0376A \end{aligned}$$

Time 4 (2.5T): (0.5 seconds)

$$\begin{aligned} I_L &= I_{MAX} (1 - e^{-(R/L)t}) \\ &= 1.2 (1 - e^{-(10/2) 0.5}) \\ &= 1.2 (0.918) \\ &= 1.1015A \end{aligned}$$

Time 5 (3T): (0.6 seconds)

$$\begin{aligned} I_L &= I_{MAX} (1 - e^{-(R/L)t}) \\ &= 1.2 (1 - e^{-(10/2) 0.6}) \\ &= 1.2 (0.950) \\ &= 1.1403A \end{aligned}$$

Assignment - Electronic Principles

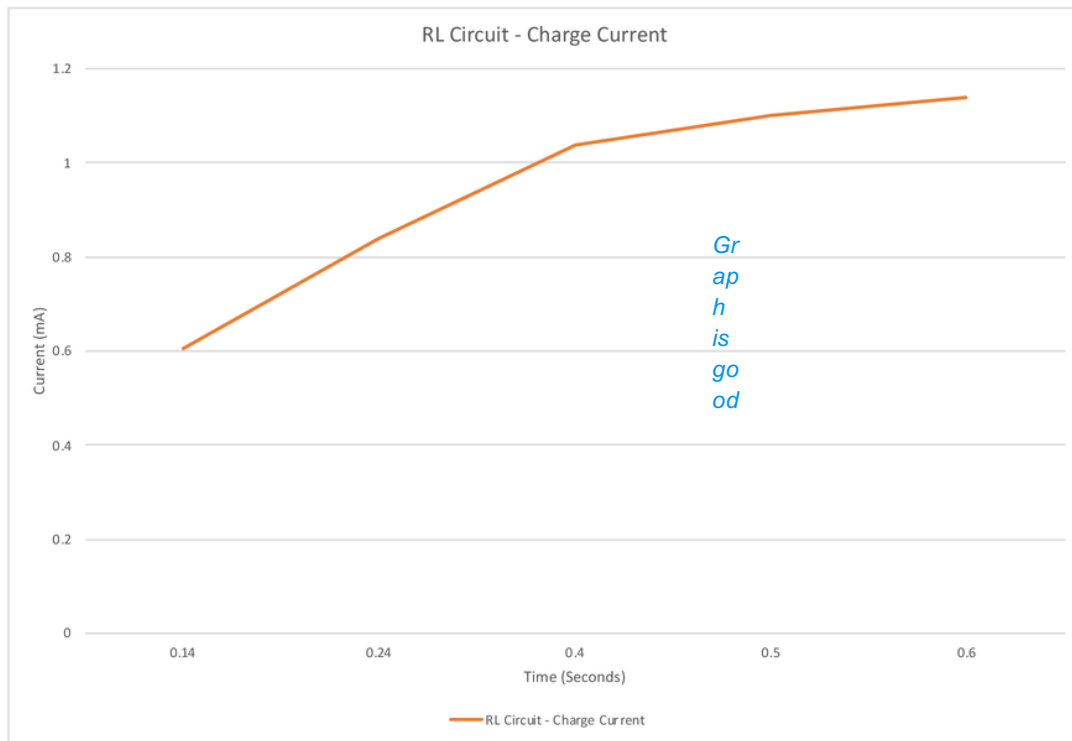


FIG 28: PLOTTED GRAPH OF R/L CIRCUIT - CHARGE CURRENT

Multisim Graph:

With the 5 times calculated and plotted, the circuit was simulated and the times added onto the graph to check the simulated values and then a comparison table can be formulated.

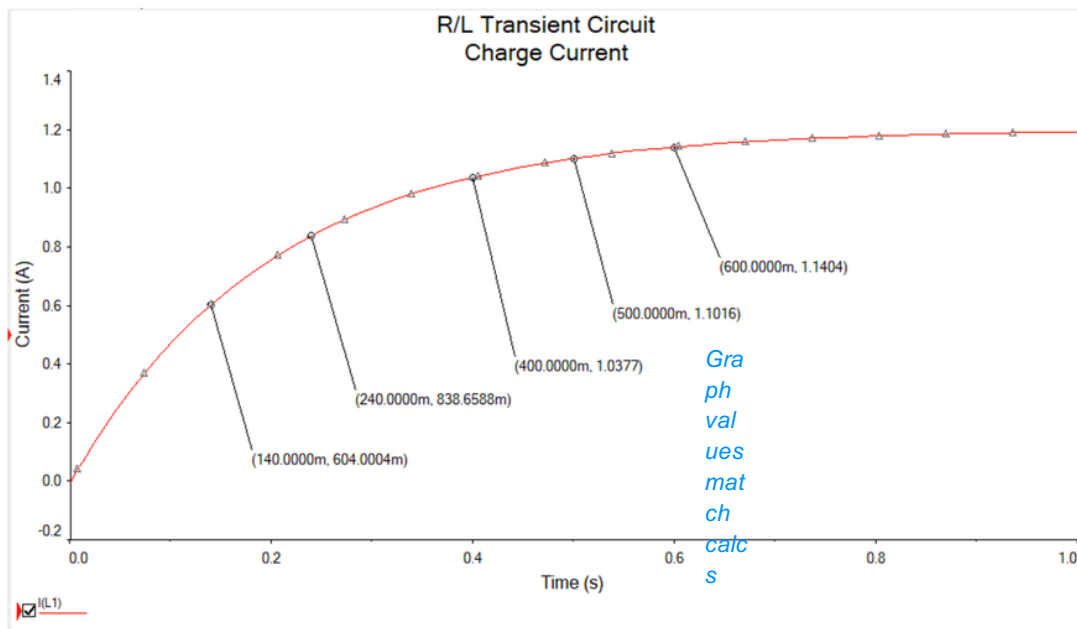


FIG 29: SIMULATED GRAPH OF R/L CIRCUIT - CHARGE CURRENT WITH TIMES

Results Comparison - Current During Charge Cycle (LR Circuit)

Time (seconds)	Simulated (mA)	Calculated (A)
0.14 (0.7T)	0.604	0.604
0.24 (1.2T)	0.63866	0.8386
0.4 (2T)	1.0377	1.0376
0.5 (2.5T)	1.1016	1.1015
0.6 (3T)	1.1404	1.1403

Table of comparison is correct and values match which show a trend. The value for sim at t= 0.24 is a typo because the calc is correct

FIG 30: COMPARISON TABLE OF R/L CIRCUIT - CHARGE CURRENT

Comments:

The calculated and simulated graphs show a consistent charge transient curve in the circuit. Some of the calculations were higher or lower than the simulated values due to figures being rounded up during the $(1 - e^{-(R/L)t})$ part of the formula.

- Determine the current flowing in the circuit immediately before the switch is changed over.

Using the formula:

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

(Where V_s represents 'Supply Voltage')

And R represents 'Resistance'

$$= 12 / 10$$

$$= 1.2A$$

Value for current is correct

- Calculate the circuit time constant and compare with estimates from manual and simulated plots.

Using the new component circuit values, we can determine the transient period (T) using the new figures:

$$T = L / R$$

(where T equals the transient time, L represents 'Inductance' and R represents 'Resistance')

$$T = L / R = 2 / 10 = 0.2 \text{ SECONDS}$$

Time constant is correct

- Calculate the time that elapses before the current flowing in the circuit has fallen to (i) 100mA, (ii) 10mA. Compare and comment with plotted value.

Rearranging the formula:

$$I_L = I_{MAX} (e^{-(R/L)t})$$

So that 't' is the unknown variable:

$$I_L = I_{MAX} (e^{-(R/L)t})$$

Assignment - Electronic Principles

$$I_L/I_{MAX} = (1 - e^{-(R/L)t})$$

$$\ln(I_L/I_{MAX}) = \ln(1 - e^{-(R/L)t})$$

$$\ln(I_L/I_{MAX}) = -(R/L)t$$

(Because $T = L/R$)

$$\ln(I_L/I_{MAX}) = -t/T$$

$$t = T(\ln(I_L/I_{MAX}))$$

(i)

$$t = T(\ln(I_L/I_{MAX}))$$

$$= 0.2(\ln(100 \times 10^{-3}/1.2))$$

$$= 0.2(\ln(0.08333))$$

$$= 0.2(-2.485)$$

$$= -0.497 \text{ Seconds}$$

The equation is correct and the instantaneous times for 10mA and 100mA are correct.

(ii)

$$t = T(\ln(I_L/I_{MAX}))$$

$$= 0.2(\ln(10 \times 10^{-3}/1.2))$$

$$= 0.2(\ln(0.008333))$$

$$= 0.2(-4.7875)$$

$$= -0.9575 \text{ Seconds}$$

Multisim Graph:

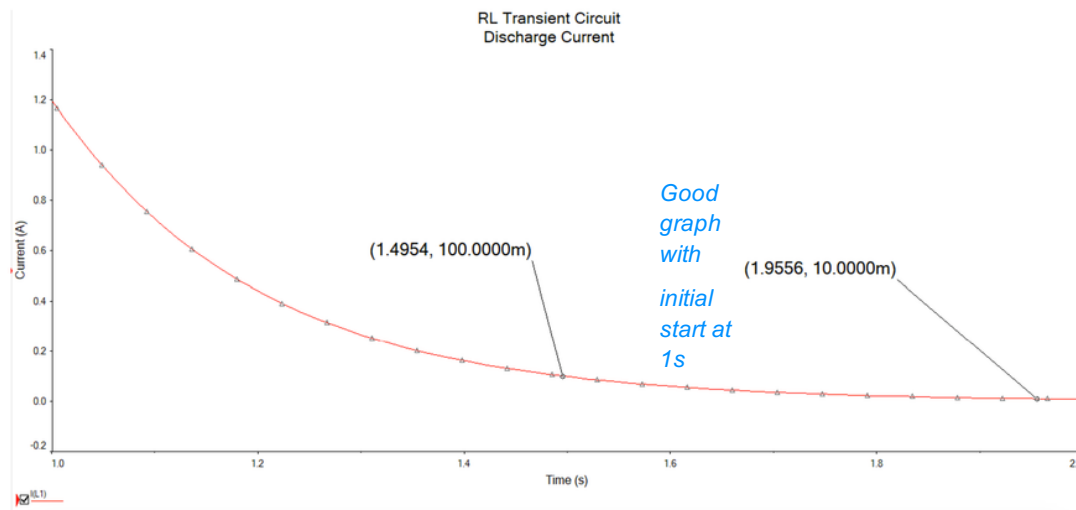


FIG 31: SIMULATED GRAPH OF R/L CIRCUIT - CHARGE CURRENT

Comments:

The graph produced by the simulation backs up the calculated values where the current is discharging in a usual transient curve where it reaches 'steady state' after 1 second.

The calculation formula provided a very accurate answer when compared with the simulated value. The simulation provides a much easier method in finding out the current because of the time axis and the ability to create a data point at any given time instance to a very accurate plot.

Conclusion:

The assignment gave a great opportunity to learn about how transients behave in different R/C and R/L circuits, and how the component values and their relationship affect the transient time. The transient curve shape shows how the capacitor acts as a short circuit and as the capacitor plates become charged and start to 'saturate' leading to less and less charge rate as time elapses.

*Short cct
initially*

The curve was also mirrored during discharge as the capacitor now acting as a power source, initially dissipates through the resistor but then loses charge exponentially.

The calculations also provided results that were VERY close to the simulated results given, but as we have pointed out previously in the report, real life measurements provided slightly different results due to:

- component values tolerances in the built circuit
- extra resistances and inductances from other components such as conductors, the multimeters and the power source
- slight time differences during the taking of measurements directly after applying the power source to taking actual readings

What was interesting to notice that despite component selection and transient time, the charge voltage increased to 50% of the applied circuit voltage after the calculated 'Transient time' of the circuit. Each graph, whether simulated or plotted through practical results, formed a perfectly shaped transient curve that was also duplicated/mirrored by the charge/discharge current.

50% of V_s was reached after $0.7T$

Table of Figures:

	Page:
FIG 1: SIMPLE R/C CIRCUIT	3
FIG 2: PRACTICAL R/C CIRCUIT SETUP	4
FIG 3: PRACTICAL RESULTS OF R/C CIRCUIT - CHARGE VOLTAGE & CURRENT	4
FIG 4: GRAPHED PRACTICAL RESULTS OF R/C CIRCUIT - CHARGE	5
FIG 5: SIMPLE R/C CIRCUIT	6
FIG 6: SIMPLE R/C CIRCUIT - CHARGE VOLTAGE	6
FIG 7: COMPARISON TABLE OF CHARGE VOLTAGE	7
FIG 8: SIMPLE R/C CIRCUIT - CHARGE CURRENT	8
FIG 9: COMPARISON TABLE OF CHARGE CURRENT	9
FIG 10: PRACTICAL RESULTS OF R/C CIRCUIT - DISCHARGE VOLTAGE & CURRENT	10
FIG 11: GRAPHED RESULTS OF R/C CIRCUIT - DISCHARGE VOLTAGE & CURRENT	10
FIG 12: SIMULATED GRAPH OF R/C CIRCUIT - DISCHARGE VOLTAGE	11
FIG 13: COMPARISON TABLE OF R/C CIRCUIT - DISCHARGE VOLTAGE	12
FIG 14: SIMULATED GRAPH OF R/C CIRCUIT - DISCHARGE CURRENT	13
FIG 15: RESULTS TABLE OF R/C CIRCUIT - DISCHARGE VOLTAGE	14
FIG 16: COMPLEX R/C CIRCUIT	15
FIG 17: COMPLEX R/C CIRCUIT SIMPLIFIED	16
FIG 18: SIMULATED GRAPH OF COMPLEX R/C CIRCUIT - CHARGE VOLTAGE	17
FIG 19: COMPARISON TABLE of COMPLEX R/C CIRCUIT - CHARGE VOLTAGE	18
FIG 20: SIMULATED GRAPH OF COMPLEX R/C CIRCUIT - CHARGE CURRENT	19
FIG 21: COMPARISON TABLE of COMPLEX R/C CIRCUIT - CHARGE CURRENT	20
FIG 22: SIMULATED GRAPH OF COMPLEX R/C CIRCUIT - DISCHARGE VOLTAGE	21
FIG 23: COMPARISON TABLE of COMPLEX R/C CIRCUIT - DISCHARGE VOLTAGE	22
FIG 24: SIMULATED GRAPH OF COMPLEX R/C CIRCUIT - DISCHARGE CURRENT	23
FIG 25: SIMULATED GRAPH OF COMPLEX R/C CIRCUIT - DISCHARGE CURRENT	24
FIG 26: SIMPLE R/L CIRCUIT	25
FIG 27: SIMULATED GRAPH OF R/L CIRCUIT - CHARGE CURRENT FOR 1 SECOND	25
FIG 28: PLOTTED GRAPH OF R/L CIRCUIT - CHARGE CURRENT	27
FIG 29: SIMULATED GRAPH OF R/L CIRCUIT - CHARGE CURRENT WITH TIMES	27
FIG 30: COMPARISON TABLE OF R/L CIRCUIT - CHARGE CURRENT	28
FIG 31: SIMULATED GRAPH OF R/L CIRCUIT - CHARGE CURRENT	29

*This table of figures should
be at the start*

Assignment - Electronic Principles

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

58/100

PAGE 1

PAGE 2

Text Comment. Table of contents is good but needs a list of figures to complement the contents

PAGE 3

Text Comment. Good intro

Text Comment. Parameters for testing have been identified

PAGE 4

Text Comment. Good clear image of setup

Text Comment. Values are good

PAGE 5

Text Comment. The graph of voltage and current are correct for the practical

Text Comment. Good graph showing significant points but why are these significant points

PAGE 6

Text Comment. ECAD graph is good

PAGE 7

Text Comment. T is identified as the time constant which is not the transient period. $T = R \times C$ and $5T$ is the transient period

Text Comment. Calcs are correct

Text Comment. Good table of values with good comparisons

PAGE 8

Text Comment. This graph is for the current discharge because it contains negative values.

Text Comment. I_{max} is identified

PAGE 9

Text Comment. Calcs are correct but should be positive values

Text Comment. The values for the charge current should be positive values going toward zero

PAGE 10

Text Comment. Good set of results and the negative values are correct here

Text Comment. The graph of the voltage and current here are correct. Values for current are negative going toward zero

PAGE 11

PAGE 12

Text Comment. Comparison of values is good and calcs match the prac and ECAD

PAGE 13

Text Comment. The graph here is incorrect. The values should start at $-I_{max}$ and climb toward zero

Text Comment. Calculations are actually correct despite the graph

PAGE 14

Text Comment. The comparison table of values are correct because the negative values are going positive with time t

Text Comment. Good conclusion for the result differences

PAGE 15

Text Comment. I_{max} is identified

Text Comment. Final value for I_{max} is correct

PAGE 16

Text Comment. Equivalent circuit is correct with parameters set for testing

Text Comment. Good explanation here and important parameters have been identified

PAGE 17

Text Comment. T is Time constant $5T$ is transient period

Text Comment. Since $0.7T$ is chosen then this should be half of V_s

PAGE 18

Text Comment. Calculations are correct and match the graph values

Text Comment. comparison table is good and values match the graph values

PAGE 19

Text Comment. Graph is not correct. There are no negative values for current during charge. The values actually match the calcs

PAGE 20

Text Comment. Calcs are the correct values but should be positive

Text Comment. Comparison of number values can be taken from the table but there are no negative values during charge

PAGE 21

Text Comment. The graph is correct but what are the values. These do not compare with calcs

Text Comment. Calc is incorrect here

PAGE 22

Text Comment. This calc is incorrect

Text Comment. Calc value is incorrect

Text Comment. The values in the table are not the calculated values

PAGE 23

Text Comment. This is a graph of charge current

PAGE 24

Text Comment. The number values of calcs are correct but graph is showing positive values

Text Comment. The table of comparisons is logical and correct if the graph can be ignored

Text Comment. The initial and final values of current are identified

PAGE 25

Text Comment. Good identification of test setup with Vs pulse input

Text Comment. Good graph

PAGE 26

PAGE 27

Text Comment. Graph is good

Text Comment. Graph values match calcs

PAGE 28

Text Comment. Table of comparison is correct and values match which show a trend. The value for sim at $t = 0.24$ is a typo because the calc is correct

Text Comment. Typo here

Text Comment. Value for current is correct

Text Comment. Time constant is correct

PAGE 29

Text Comment. The equation is correct and the instantaneous times for 10mA and 100mA are correct.

Text Comment. Good graph with initial start at 1s

PAGE 30

Text Comment. Short cct initially

Text Comment. 50% of V_s was reached after 0.7T

PAGE 31

Text Comment. This table of figures should be at the start

GRADING FORM: CSG-RUBIC

RHYS DAVIES

0

RESEARCH-INFORMED LITERATURE



N/a

KNOWLEDGE AND UNDERSTANDING



introduction was informative and gave a logical description of the tasks. 5.5/10 Results and discussion were consistent and demonstrated an understanding. There are errors present in the tasks and some of the ECAD graphs are in the wrong sections. The explanations demonstrate that there is an understanding for the tasks. 8.5/15

14/25

ANALYSIS



The testing was carried out efficiently with good explanations of procedures. The calculations are mostly correct but there are some errors and the wrong graphs in certain areas. Explanations showed an understanding but there was some confusion in the analysis. The tables of comparison were good and effective in the analysis. 17.5/30 Conclusions were present after each task and at the end of the report but some points were unclear. 5.5/10

23/40

PRACTICAL APPLICATION AND DEP.



The circuit testing was carried out using good relevant methods and this required an understanding to set this up. good results were obtained. 9.5/15 The quality of test results was good and backed up with explanations (some with minor errors). 5.5/10

15/25

SKILLS FOR PROFESSIONAL PRAC.



The quality of the report was good despite some errors. 6/10

6/10