

1103509

by Declan Jones

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Course: HNC Electrical and Electronic Engineering

Module: SGEE4000 Electrical and Electronic Principles

Assignment: Investigation into DC Transients

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Word count: 1921

- ① KNOWLEDGE & UNDERSTANDING HAS BEEN DEMONSTRATED.
- ② GOOD FEEDBACK & COMMENTS.

MARK AS RECD.

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1. Transient behaviour for the charging/discharging of a capacitor

The first two tasks can be combined where they request the charging/discharging of a resistor/capacitor circuit. Three random time constant values are selected to ensure that the data varies from other classmates. These are 45, 120 and 190 seconds for the charging circuit and 30, 90 and 165 seconds for the discharging circuit. When considering the time constant of the circuit and running the simulation to show the discharge curve immediately following the charging curve, the selected times are added on the to multiple of 5 time-constants, so we end up with the graph that is 10 constants in time.



1.1 Calculations

The time constant is calculated by multiplying the resistance and the capacitance of the circuit.

$$\tau = RC = (5600 \times 10000 \times 10^{-6}) = 56 \text{ seconds}$$

$$5\tau = 280 \text{ seconds}$$

Firstly, the charging/discharging voltages and currents are calculated, where V is 5V determined by the circuit, RC is the time constant calculated above, and t are the randomly selected times.

Charging voltages:

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

$$V_c \text{ at 45 seconds} = 5 \left(1 - e^{-\frac{45}{56}} \right) = \mathbf{2.7614 \text{ V}}$$

$$V_c \text{ at 120 seconds} = 5 \left(1 - e^{-\frac{120}{56}} \right) = \mathbf{4.4134 \text{ V}}$$

$$V_c \text{ at 190 seconds} = 5 \left(1 - e^{-\frac{190}{56}} \right) = \mathbf{4.8319 \text{ V}}$$

Charging currents:

$$I_{max} = \frac{V - V_c}{R} = \frac{5\text{V} - 0}{5600\Omega} = \mathbf{892.857\mu\text{A}}$$

$$I \text{ at 45 seconds} = 892.857(e^{-\frac{45}{56}}) = \mathbf{399.756\mu\text{A}}$$

$$I \text{ at 120 seconds} = 892.857(e^{-\frac{120}{56}}) = \mathbf{104.749\mu\text{A}}$$

$$I \text{ at 190 seconds} = 892.857(e^{-\frac{190}{56}}) = \mathbf{30.011\mu\text{A}}$$

Discharging voltages:

$$V_c \text{ at 30 seconds} = 5 \left(e^{-\frac{30}{56}} \right) = \mathbf{2.9266 \text{ V}}$$

$$V_c \text{ at 90 seconds} = 5 \left(1 - e^{-\frac{90}{56}} \right) = \mathbf{1.0023 \text{ V}}$$



$$V_c \text{ at 165 seconds} = 5 \left(1 - e^{-\frac{165}{56}} \right) = \mathbf{0.2626 \text{ V}}$$

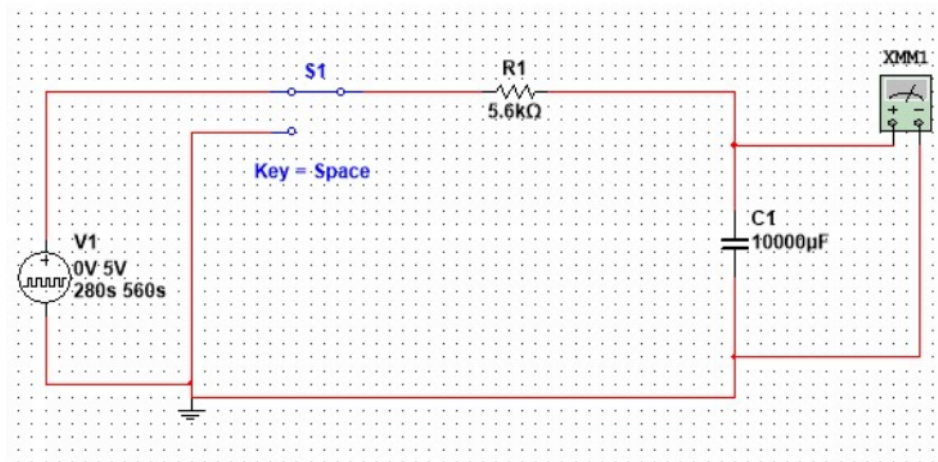
Discharging currents:

$$I \text{ at 30 seconds} = 892.857 \left(e^{-\frac{30}{56}} \right) = \mathbf{522.5455 \mu A}$$

$$I \text{ at 90 seconds} = 892.857 \left(e^{-\frac{90}{56}} \right) = \mathbf{178.9817 \mu A}$$

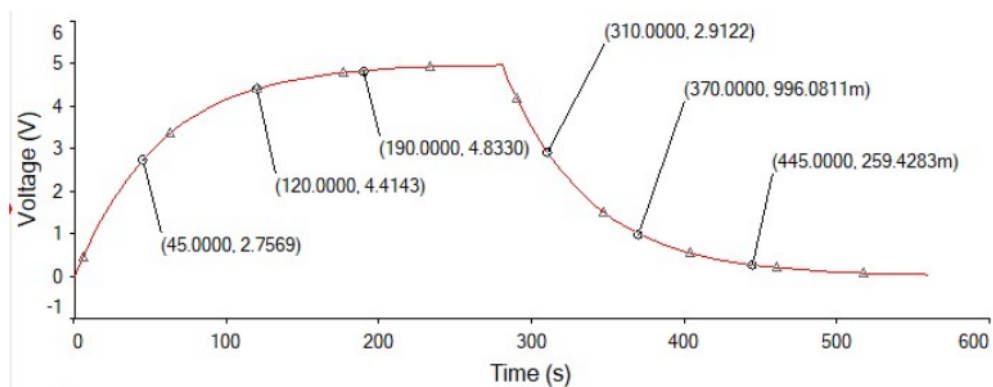
$$I \text{ at 165 seconds} = 892.857 \left(e^{-\frac{165}{56}} \right) = \mathbf{46.899 \mu A}$$

1.2 Circuit simulation



The circuit is redrawn in Multisim in preparation to complete the simulation results. As we know that the time constant is 56 seconds, 5 times this is 280 seconds. To get the charging and discharging voltages on one graph, this can be done by using a step style DC source, which will give 5V for the first 280 seconds (5τ) and shut off to 0V up until 560 seconds (10τ).

Voltages for the charging/discharging of the capacitor:

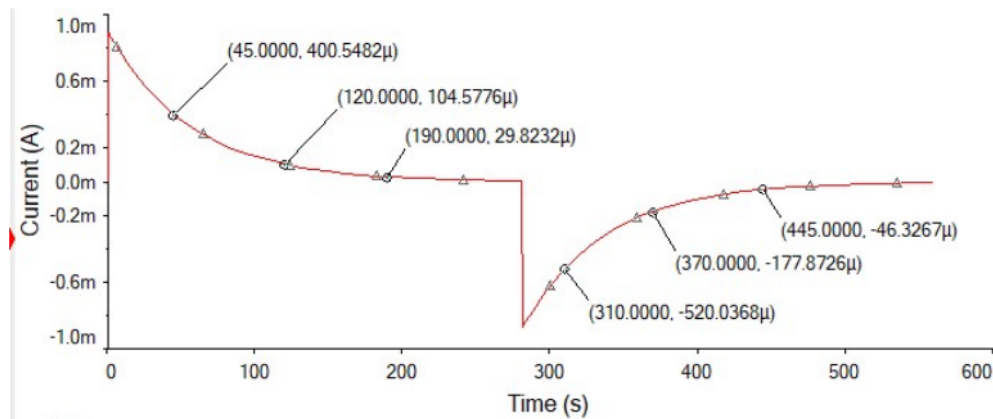


By running a DC transient graph, we get the voltage curve for the charging and discharging of the circuit. The selected times can then be added as data points to give the corresponding voltages.

As expected, the graph starts off at 0V and increases sharply before exponentially dropping off until it reaches steady state. The same is the case for the discharge but the opposite, following second order differential curves. (Bird, 2010).



Current for the charging/discharging of the capacitor:



The DC transient graph can also be run to show the current in the circuit when charging/discharging. This has a different trend in respect to the relationship between the charging/discharging voltages. When steady state is reached, and the circuit begins to dissipate, the current is shown as a negative, until it reaches steady state of 0A again. This is relative to the current flow in the system, and hence why it is represented like this. The readings are also added as data points, so the data can be extrapolated into a comparison table.

1.3 Comparison of results

All the data collected from the practical, theoretical calculations and Multisim simulation are put into a table for ease of comparison.

Charging circuit			
	Practical	Theoretical	Simulation
Voltage at 45 seconds	3.39V	2.7614V	2.7569V
Voltage at 120 seconds	5.35V	4.4134V	4.4143V
Voltage at 190 seconds	5.86V	4.8319V	4.8330V
Charging circuit			
	Practical	Theoretical	Simulation
Current at 45 seconds	450 μ A	399.756 μ A	400.5482 μ A
Current at 120 seconds	120 μ A	104.749 μ A	104.5776 μ A
Current at 190 seconds	40 μ A	30.011 μ A	29.8232 μ A
Discharging circuit			
	Practical	Theoretical	Simulation
Voltage at 30 seconds	3.56V	2.9266 V	2.9122V
Voltage at 90 seconds	1.24V	1.0023 V	0.9961V
Voltage at 165 seconds	0.34V	0.2626 V	0.2594V
Discharging circuit			
	Practical	Theoretical	Simulation
Current at 30 seconds	590 μ A	522.5455 μ A	520.0368 μ A
Current at 90 seconds	200 μ A	178.9817 μ A	177.8726 μ A
Current at 165 seconds	50 μ A	46.899 μ A	46.3267 μ A

When comparing the readings of the practical, theoretical and simulation, there are some obvious discrepancies. The largest of these discrepancies is the practical results when compared against the others, this is where the largest difference can be seen.

The reason for this is that the circuit in the supplied video of the simulation had a DC voltage of 6V, in comparison to the 5V that is stated in the brief of the assignment. This has a profound result on the basis that it does mean that all the data has a discrepancy, but it is still a worthwhile comparison.

The 6V circuit has a voltage that is 20% higher than the specified 5V, and although the relationships with the time constant are not linear, the relationship between the three sets of data shows that the theoretical are in line with the rest. The theoretical vs the simulation is impressively accurate, this is most likely down to the fact that the data was calculated and kept at 4 decimal place values. This means that rounded errors are minimal, but not eradicated. The Multisim programme takes in to account the affecting factors of the other components in the circuit such as resistance and these alter the numbers from those calculated.

Even if the supply for the practical had been altered to 5V, there would have been a relatively large discrepancy to the calculated and the theoretical. To begin with, the frame rate of the video means that it cannot be paused at the exact moment to get the specific time. Also, the multimeters' themselves would have a tolerance and only round to 2 decimal points. The supply would also fluctuate slightly as it maintains the selected value. Taking all these factors into account, the data recorded was as expected, and seemed in keeping when compared to the rest of the readings.

Taking a more in depth look at a particular result,

Voltage at 30 seconds	3.56V	2.9266 V	2.9122V
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This shows the discharging voltage at 30 seconds, (left to right, practical, theoretical and simulation). Carrying most of the decimal places has meant the accuracies of the simulation and calculation are very good. As previously mentioned, the 3.56V is 0.633V higher due to the higher supply voltage used on the practical.

If we assume the relationship is linear for proving purposes, and we divide the value by 6 and multiply by 5 then we get 2.966V. This is very interesting and positive, as when the terms that applied to the 5V circuit are calculated to give the percentage of the value obtained in the practical, the value is only 0.04V off the calculated. This proves that although the practical used a slightly higher supply, the expected readings would be achieved. Had the measuring equipment used been more sensitive, this reading may have been even closer.

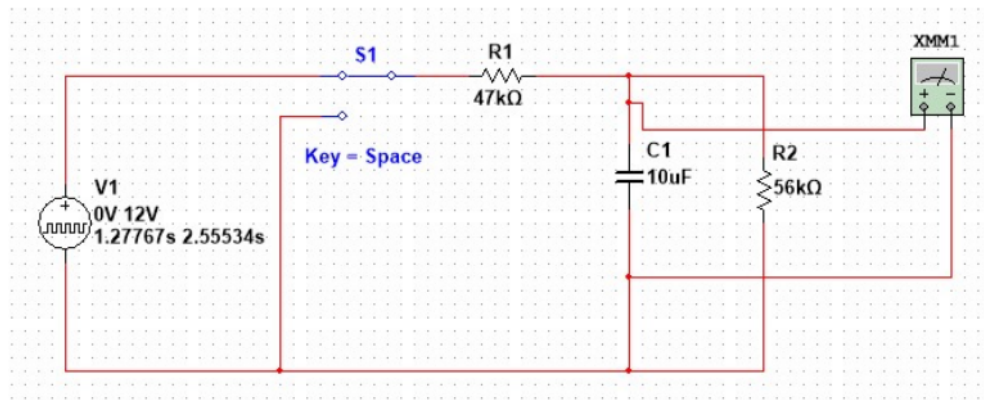


2. Transient behaviour for a more complex circuit

Following Thevenin's' rule, where resistors in parallel can be calculated to give a theoretical single resistance in the circuit, this is calculated and then allows the time constant to be estimated (Bird, 2010).

$$R_t = \left(\frac{R_1 \times R_2}{R_1 + R_2} \right) = \left(\frac{47000 \times 56000}{47000 + 56000} \right) = 25553.4 \, \Omega \text{ or } 25.6K\Omega$$

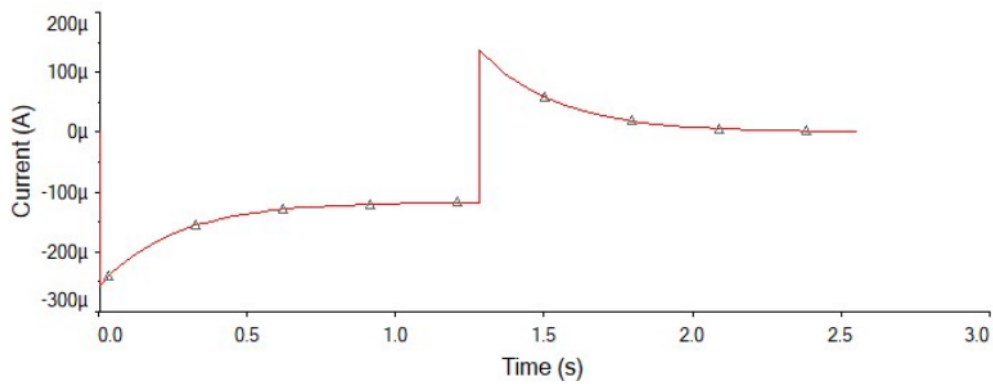
$$V = 12 \left(\frac{56000}{47000 + 56000} \right) = 6.5V$$

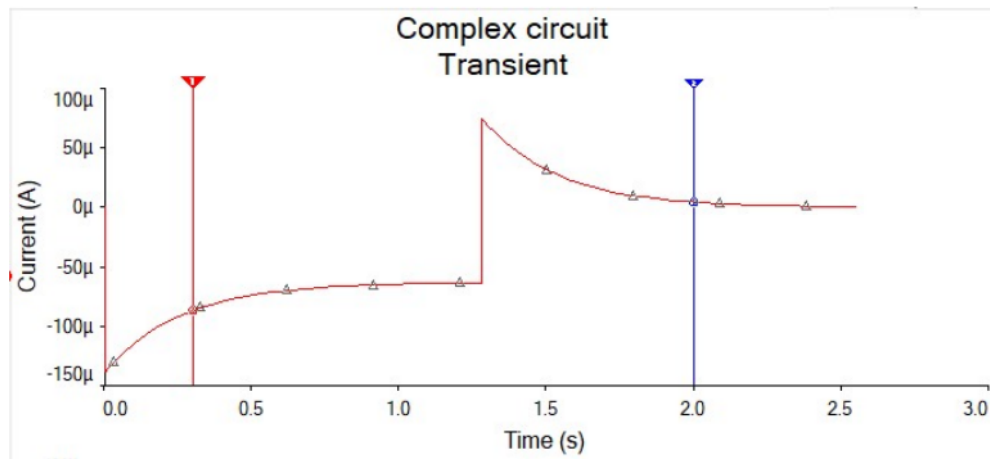


$$\tau = RC = (25553.4 \times 10000 \times 10^{-6}) = 0.255534 \text{ seconds}$$

$$5\tau = 1.27767 \text{ seconds}$$

$$10\tau = 2.55534 \text{ seconds}$$





$$I_{max} = \frac{V}{r} = \frac{6.5}{25534} = 0.254mA$$

$$36.8\% \text{ of } I_{max} = 0.094mA$$

Charge:

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

$$I = I_{max} (e^{-1}) = 0.254 \times 10^{-3} \times (0.368) = 9.3472 \times 10^{-5} A$$

Discharge:

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

$$I = I_{max} (e^{-1}) = -0.254 \times 10^{-3} \times (0.368) = -9.3472 \times 10^{-5} A$$

The charge and discharge time constant currents are as expected, a relatively small value which is shown for both. The curve is of the same profile for the charge and discharge, which shows that the circuit has the same characteristic for both operations. Bird states that "when a voltage is applied to a capacitor C and resistor R connected in series, there is a short period of time immediately after the voltage is connected, during which the current flowing in the circuit and voltages across C and R are changing."

This is the potential difference we are capturing in these simulations, and hence the values for the current time constant are much narrower than those of the voltage time constants.

3. Transient behaviour for the inductive circuit

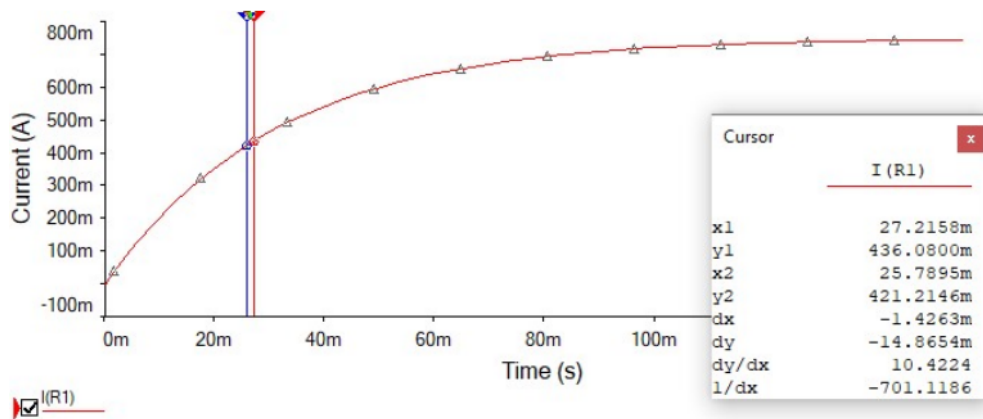
Maximum current approximately 690mA.



$$0.632 \times 690\text{mA} = 436.08\text{mA}$$

$$\tau = 27.22 \text{ seconds}$$

$$5\tau = 27.22\text{s} \times 5 = 136.1 \text{ seconds}$$



The transient behaviour in the inductive circuit is as explained by Bird. The Current starts at zero, and as the time constants progress, the current rises until it reaches steady state, getting exponentially closer to the 100% of its current pull.

It would be interesting to see the difference in current if the size of the inductor was fluctuated and also the supply had a higher/lower value. The estimation of the current can be calculated to give the max value which would likely be within 5% of the value above. Furthermore, the voltage does not have the same characteristics in the capacitive circuits shown throughout the reports.

If the task were to be completed again, all calculations would be conducted as in previous tasks to get the theoretical values of the data such as time constants, and then possible compared with a similar circuit to analyse the variations and understand the relationship that altering certain factors would give.



4. Conclusions and recommendations

Regarding the first and second tasks, it can be considered they were complete and satisfactorily answered all the points requested in the brief. The circuits were drawn in Multisim, and there the simulations could be carried out.

The graphs give a good visual representation to what the circuit characteristics are regarding voltage and current, and the results are as expected and as calculated. This solidifies the understanding of this circuit and means that it can be considered successful.

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There are learning points that can be taken from completing these tasks. First, it may be a more visually appealing to the report reader if the data were rounded down to two decimal places. It may be argued that this would give more rounded errors, and this would be true, but data is only as good as the weakest link when in a comparison chart, which in this instance would be the readings obtained from the multimeters in the practical section.

Looking at the third task, this incorporates two resistors in parallel which is then considered to be a complex problem. The circuit must be looked at with the perception that it has one resistance and one capacitance. To do this, Thevenin's rule has to be followed. This takes in to account the parallel resistors and allows us to calculate one resistance for the circuit, so we can consider it a simple circuit once again. It would be interesting to follow any other ideologies with this in mind, although the readings are confirmed with the Matlab  12, there would be circumstances where access to the programme may not be possible, in this instance it gives more confidence if a variety of means are attempted, possibly by running a practical study, like the first and second tasks.

The inductance circuit follows the transient curve of the current in the circuit provided in the brief. More time should have been spent with this section of the report to get a deeper analysis and understanding of the issue. This emphasises the importance in a thorough understanding of all the circuit types that were provided in the brief, as opposed to the reality of over focusing on the earlier tasks and possibly by investing too much time in these. The inductor circuit was simulated and fully understood, but the capacitive circuits earlier on in the report show where the competence on knowledge lies.

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Recommendations would also include carrying out a practical test with the same supply voltage as simulated and practical just to compare values to the same data points, although using one with a slightly different voltage did have learning outcomes, as it showed the relationship to be near linear and nearer than may have been estimated.

5. Appendices

Bird, J., 2010. *Electrical and Electronic Principles and Technology*. 4th ed. s.l.:Newnes.

FINAL GRADE

GENERAL COMMENTS

Instructor

68/100

PAGE 1

PAGE 2

PAGE 3



Comment 1

Include an introduction



Comment 2

There is only one time constant value for any particular circuit configuration

PAGE 4

PAGE 5



Comment 3

why has the equation changed? mistake?

PAGE 6

PAGE 7



Comment 4

incorrect, first order system only

PAGE 8



Comment 5

correct analysis



Comment 6

not required



Comment 7

you have worked this out correctly, well done



Comment 8

explain narrower in more detail



Comment 9

some errors here, need to see full workings to see where you went wrong



Comment 10

there are aspects of this task missing



Comment 11

success criteria should not be based on understanding



Comment 12

matlab was not used



Comment 13

a conclusion should not be about where your time was allocated, it should summarise the results and overall analysis

GRADING FORM: NEW CSG-RUBRIC

DECLAN JONES

68

1. ENGAGEMENT WITH LITERATURE



NA

0

2. KNOWLEDGE AND UNDERSTANDING



Competent knowledge and understanding in some areas, introduction of theme and results, however errors and omissions cast a ^{SHADOW} show of doubt on your overall understanding of basic concepts, see comments. 17/25

17

3. COGNITIVE AND INTELLECTUAL



A sound analysis and you have obviously understood the experimental procedures, there are some errors and omissions. 21/30

21

4. PRACTICAL APPLICATION



Circuit testing very good and quality of test results also very good overall, save a few errors as marked. 17/25

17

5. TRANSFERABLE SKILLS



Report includes accurate results and the quality of the overall report is good and written in a coherent manner, see comments.

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