

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Byron Grey	Student ID number:	
Programme:	HNC Electrical/Electronic Engineering & Instrumentation Engineering		
Module:	Electrical Principles		
Module code:	PCEE4001	Contribution to Overall Module Assessment (%):	100%
Lecturer:	Jason Pointer	Internal Verifier:	Nigel Richards
Assignment Title:	Electrical Principles	Word count (or equivalent):	2000
Submission deadline:	11/01/23	Return date of provisional marks & written feedback:	25/01/23
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)

1. Produce routine solutions to typical electrical problems.
2. Relate and apply basic electrical theory to collected data.

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	15	10.2
Engagement with a wide range of literature sources, including sources retrieved independently. Generally sound referencing, with very few inaccuracies or inconsistencies.		
2. Knowledge and Understanding Skills	30	21.4
Task 1 achieved 75%. Task 2 achieved 77%, Task 3 achieved 58%. Task 4 achieved 75%. Excellent knowledge and understanding of the basic underlying concepts and principles of the subject. Showed excellent understanding of the calculated requirements but did use the wrong values in Task 3. The research work was very good that used a variety of source material.		
3. Cognitive and Intellectual Skills	10	5.9
Task 1 achieved 68%. Task 4 achieved 50%. Good evaluation of the underlying concepts and principles for Task 1 and 4.		
4. Practical Application Skills	35	28.7
Task 1 achieved 82%. Task 4 achieved 82%. An excellent application of practical work for Task 1 and 4, very good use of the test equipment to obtain all of the required results.		
5. Transferable Skills for Life and Professional Practice	10	6.8
Work is accurate, coherent, fluent, well-structured and organised.		

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		73%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David



COLEG Sir Benfro
Pembrokeshire COLLEGE

Electrical Principles

Assignment 1

HNC Electrical and Electronic Engineering

Byron Grey

Student Number- 2221716

Email- 173589@pembrokeshire.ac.uk

Content Page

Task 1	3
Task 2	8
Task 3	12
Task 4	21
Reference list.....	25
Bibliography.....	26

Task 1

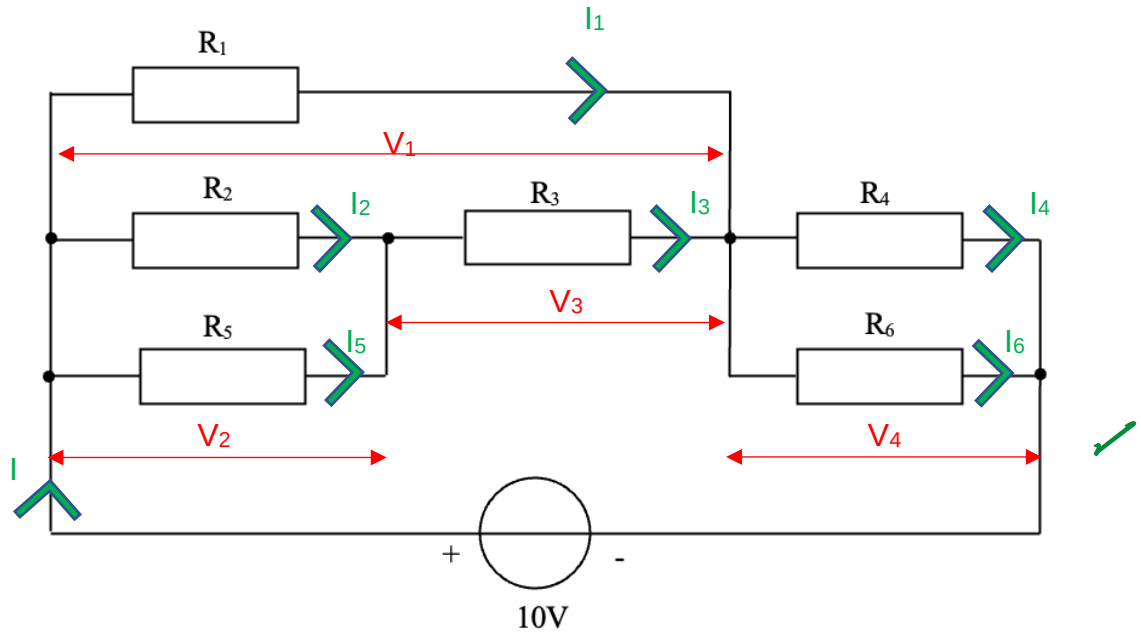


Figure 1 – Resistors in Series/Parallel

Table 1 – values for Task 1

Student Number	R_1 (k Ω)	R_2 (Ω)	R_3 (Ω)	R_4 (Ω)	R_5 (Ω)	R_6 (Ω)
4	6.8	270	220	560	330	560

1.

Construct the circuit and measure the total resistance (R_T) before connecting the power supply.

Using a bread board, the circuit was constructed following the diagram above and measured the total resistance (R_T).

2.

Connect a 10V supply and measure the p.d. value across each resistor, the supply current and the current in each resistor.

A 10V supply was connected and measured the p.d value across each resistor, the supply current and the current in each value, seen below.

Practical Results

$R_T = 626\Omega$ ✓

Voltage across:

$R_1 = 5.51V$ ✓

$R_2 = 2.22V$ ✓

$$R_3 = 3.26V$$

$$R_4 = 4.46V$$

$$R_5 = 2.22V$$

$$R_6 = 4.46V$$

Current:

$$I = 15.82mA$$

$$I_1 = 0.803mA$$

$$I_2 = 8.26mA$$

$$I_3 = 14.96mA$$

$$I_4 = 7.91mA$$

$$I_5 = 6.75mA$$

$$I_6 = 7.89mA$$

Well done.

3.

Calculate the

- total resistance, R_T
- Supply current, I
- current in each resistor
- the p.d. value across each resistor
- and the power dissipated in each resistor.

All formulas and workings must be shown.

The calculations for the total resistance, the supply current, current in each resistor, the p.d value across each resistor and the power dissipated in each resistor are seen in the following calculations.

Calculated Results

$$R_{25} = \frac{R_2 \times R_5}{R_2 + R_5} = \frac{270 \times 330}{270 + 330} = 148.5\Omega$$

$$R_{235} = R_{25} + R_3 = 148.5 + 220 = 368.5\Omega$$

$$R_{1235} = \frac{R_1 \times R_{235}}{R_1 + R_{235}} = \frac{6800 \times 368.5}{6800 + 368.5} = 349.56\Omega$$

$$R_{46} = \frac{R_4 \times R_6}{R_4 + R_6} = \frac{560 \times 560}{560 + 560} = 280\Omega$$

$$R_T = R_{1235} + R_{46} = 349.56 + 280$$

$$R_T = 629.56\Omega$$

$$I = \frac{V}{R_T} = \frac{10}{629.56}$$

$$I = 15.88\mu A$$

$$V_4 = I \times R_{46} = 15.88 \times 10^{-6} \times 280$$

$$V_4 = 4.45V$$

$$I_4 = \frac{V_4}{R_4} = \frac{4.45}{560}$$

$$I_4 = 7.95\mu A$$

$$I_6 = \frac{V_4}{R_6} = \frac{4.45}{560}$$

$$I_6 = 7.95\mu A$$

$$V_1 = V - V_4 = 10 - 4.45$$

$$V_1 = 5.55V$$

$$I_1 = \frac{V_1}{R_1} = \frac{5.55}{6800}$$

$$I_1 = 0.816\mu A$$

$$I_3 = I - I_1 = 15.88 \times 10^{-6} - 0.816 \times 10^{-6}$$

$$I_3 = 15.06\mu A$$

$$V_3 = I_3 \times R_3 = 15.06 \times 10^{-6} \times 220$$

$$V_3 = 3.31V$$

$$V_2 = V_1 - V_3 = 5.55 - 3.31$$

$$V_2 = 2.24V$$

$$I_2 = \frac{V_2}{R_2} = \frac{2.24}{270}$$

$$I_2 = 8.30\mu A$$

$$I_5 = \frac{V_2}{R_5} = \frac{2.24}{330}$$

$$I_5 = 6.79\mu A$$

Power over each resistor

$$P = I \times V$$

$$P_1 = I_1 \times V_1 = 0.816 \times 10^{-6} \times 5.55$$

$$P_1 = 4.53\mu W$$

$$P_2 = I_2 \times V_2 = 8.30 \times 10^{-6} \times 2.24$$

$$P_2 = 18.60mW$$

$$P_3 = I_3 \times V_3 = 15.06 \times 10^{-3} \times 3.31$$

$$P_3 = 49.85mW$$

$$P_4 = I_4 \times V_4 = 7.95 \times 10^{-3} \times 4.45$$

$$P_4 = 35.38mW$$

$$P_5 = I_5 \times V_2 = 6.79 \times 10^{-3} \times 2.24$$

$$P_5 = 15.21mW$$

$$P_6 = I_6 \times V_4 = 7.95 \times 10^{-3} \times 4.45$$

$$P_6 = 35.38mW$$

Excellent set of calculations.
well done.

4.

Comment on the practical and calculation results, discussing any variations when comparing these results, referring to relative theories such as Kirchhoff's laws and how they relate to the results.

Comparison

Table 2 – Comparison of calculated and practical results

	<u>Calculated Results</u>	<u>Practical Results</u>
R _T	629.56Ω	626Ω
R ₁	5.55V (V ₁)	5.51V
R ₂	2.24V (V ₂)	2.22V
R ₃	3.31V (V ₃)	3.26V
R ₄	4.45V (V ₄)	4.46V
R ₅	2.24V (V ₂)	2.22V
R ₆	4.45V (V ₄)	4.46V
I	15.88mA	15.82mA
I ₁	0.896mA	0.803mA
I ₂	8.30mA	8.26mA
I ₃	15.06mA	14.96mA
I ₄	7.95mA	7.91mA
I ₅	6.79mA	6.75mA
I ₆	7.95mA	7.89mA

Looking at the calculated results compared to the practical results there are slight variations with all the results, and this could be down to many factors. Firstly, the value on the resistors has a tolerance of plus or minus 5%, therefore they will not be the exact values. For example, with the $6.8\text{k}\Omega$ resistor, this could have resistance anywhere between $6.46\text{k}\Omega$ and $7.14\text{k}\Omega$. Factors may also come from the testing equipment of the multimeter and leads, to start with the lead, they could have bad continuity if they are dirty and causing poor contact. With the multimeter we do not know how accurate the equipment is as it will have a loading effect, which means it has an internal resistor of $10\text{m}\Omega$ when the meter is put in parallel creating a drop in total resistance and once measuring current it puts it in series so will increase. ✓

Another factor that could affect the results is human error, this can affect the calculated and the practical results. Rounding the calculation results can affect the outcome as you can be using rounded numbers to work out further results. Human error can also affect the practical results when holding the leads on the circuit, they may not get a good contact and can affect the continuity. ✓

Looking at the results you will also see both of Kirchhoff's Laws. You will see his Current law when looking at the calculation of $I_2 + I_5 = I_3$ as this can be represented the same as the law, which states "The total current flowing towards a junction point is equal to the total current flowing away from that junction point" (U. A. Bakshi, 2009, p. 2-23). ✓ You can also see Kirchhoff's Voltage Law which states "In Any network, the algebraic sum of the voltage drop across the circuit element of any closed path (or loop or mesh) is equal to the algebraic sum of the e.m.f's in the path" (U. A. Bakshi, 2009, p. 2-23). This is seen in the circuit above with $V_2 + V_3 = V_1$ and $V_1 + V_4 = V$. ✓

Task 2

1.

A capacitor is an electronic device that stores electrical charge and is used in a number of electronic applications. Explain the construction of the capacitor, include methods that could be used to alter the value of the capacitor.

Wildi states that “A capacitor stores energy in its electric field whenever a voltage E appears across its terminals. The energy is given by $W = \frac{1}{2}CE^2$, Where $W =$ *Energy stored in the capacitor (J)*, $C =$ *Capacitance of the Capacitor (F)*, $E =$ *Voltage (V)*” (T. Wildi, 2013, p. 23).

Figure 2 illustrates the basic construction of a capacitor, which is similar in all capacitors and is made up of two conductive plates, connecting wires, an electric field, and a dielectric region. The two conductive plates are made up of materials such as copper, brass and aluminium and will be placed in close proximity but will not touch each other. The space in-between these plates is known as the dielectric region and will be filled with a non-conductive material such as vacuum, glass, liquid, or air.

As both plates are good conductors of electricity this means that electric current can pass through them and allows the plates to hold and store the electric charge, this is the case with a capacitor. Physics and Radio Electronics states that “the dielectric medium or material block the flow of charge carriers (especially electrons) between the conductive plates” (Physics and Radio Electronics, 2015). This means that the electric charge will be trapped and stored within the two plates, allowing it to build up ready to be discharged.

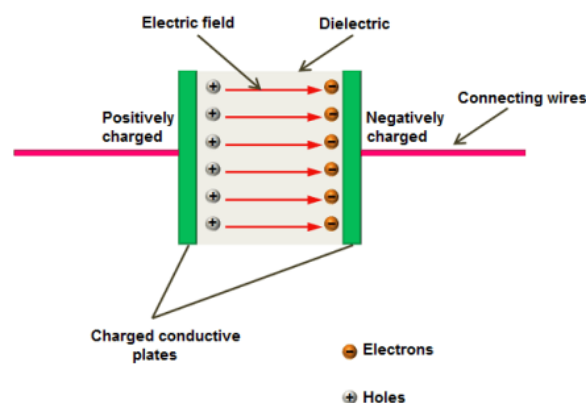


Figure 2 – Capacitors in series/parallel (Physics and Radio Electronics, 2015)

All capacitors will have its own capacitance value, which will determine how much energy can be stored. This is proved in the equation of $W = \frac{1}{2}CE^2$ as when the capacitance of the capacitor is increased so will the energy stored within it. The method of changing the capacitance of a capacitor is the variations of the plate area, distance between the plates and dielectrics in relation to being able to support the electrostatic forces. ✓

Hughes states that “that the capacitance of a capacitor is proportional to the area of the plates” (Hughes, 2016, p. 102), this is shown when putting two similar capacitors in series the capacitance is doubled with it, however all that has happened is the area of each plate has doubled. Hughes also says, “that the capacitance of a capacitor is inversely proportional to the distance between the plates” (Hughes, 2016, p. 102) and this is shown when having two capacitors in series the capacitance is halved due to having double the thickness of insulations between the plates. From these relationships the capacitance can be shown in the equation of ✓

$$\text{Capacitance} \propto \frac{\text{Area of plates}}{\text{Distance between plates}}.$$

For this to work the dielectric cannot be ignored as the space between the conductors will need to be filled with an insulator to stop the charges from moving towards each other and dissipating. ✓ *Very well written*

2.

Figure 2 shows a circuit containing capacitors in series/parallel to a d.c. voltage source.

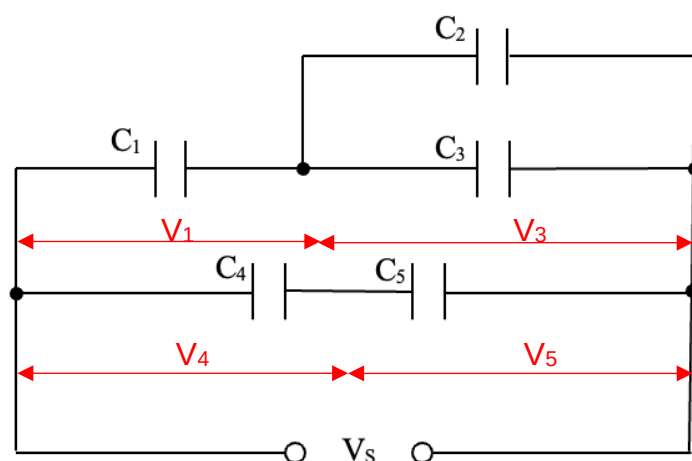


Figure 3– Capacitors in series/parallel

Table 3 – Values for Task 2

Student Number	C ₁ (μF)	C ₂ (μF)	C ₃ (μF)	C ₄ (μF)	C ₅ (μF)	V _s (V)
4	27	22	47	22	27	25

Using the values stated in Table 3, determine:

- the equivalent circuit capacitance
- the total charge
- the charge in each capacitor
- the energy stored in each capacitor
- the total energy stored in the circuit.

a)

$$C_{23} = C_2 + C_3 = 22 + 47 = 69\mu F$$

$$C_{123} = \frac{C_1 \times C_{23}}{C_1 + C_{23}} = \frac{27 \times 69}{27 + 69} = \frac{1863}{96} = 19.41\mu F$$

$$C_{45} = \frac{C_4 \times C_5}{C_4 + C_5} = \frac{22 \times 27}{22 + 27} = \frac{594}{49} = 12.12\mu F$$

$$C_T = C_{123} + C_{45} = 19.41 + 12.12$$

$$C_T = 31.53\mu F$$

b)

$$Q_T = C_T \times V = 31.53 \times 25$$

$$Q_T = 788.25\mu C$$

c)

$$(Q_4 = Q_5) = Q_{45} \times V = 12.12 \times 25$$

$$Q_4 = 303\mu C$$

$$Q_5 = 303\mu C$$

$$Q_1 = Q_T - Q_{45} = 788.25 - 303$$

$$Q_1 = 485.25\mu C$$

$$V_1 = \frac{Q_1}{C_1} = \frac{485.25}{27}$$

$$V_1 = 17.97V$$

$$V_3 = V - V_1 = 25 - 17.97$$

$$V_3 = 7.03V$$

$$Q_2 = C_2 \times V_3 = 22 \times 7.03$$

$$Q_2 = 154.66\mu C$$

$$Q_3 = C_3 \times V_3 = 47 \times 7.03$$

$$Q_3 = 330.41 \mu C$$

d)

$$W_1 = \frac{1}{2} \times C_1 \times V_1^2 = \frac{1}{2} \times 27 \times 17.97^2$$

$$W_1 = 4359.43 \mu J = 4.36 mJ$$

$$W_2 = \frac{1}{2} \times C_2 \times V_3^2 = \frac{1}{2} \times 22 \times 7.03^2$$

$$W_2 = 543.63 \mu J$$

$$W_3 = \frac{1}{2} \times C_3 \times V_3^2 = \frac{1}{2} \times 47 \times 7.03^2$$

$$W_3 = 1161.39 \mu J$$

$$V_4 = \frac{Q_4}{C_4} = \frac{303}{22}$$

$$V_4 = 13.77 V$$

$$V_5 = \frac{Q_5}{C_5} = \frac{303}{27}$$

$$V_5 = 11.22 V$$

$$W_4 = \frac{1}{2} \times C_4 \times V_4^2 = \frac{1}{2} \times 22 \times 13.77^2$$

$$W_4 = 2085 \mu J$$

$$W_5 = \frac{1}{2} \times C_5 \times V_5^2 = \frac{1}{2} \times 27 \times 11.22^2$$

$$W_5 = 1699.49 \mu J$$

e)

$$W_T = \frac{1}{2} \times C_T \times V^2 = \frac{1}{2} \times 31.53 \times 25^2$$

$$W_T = 9853.13 \mu J$$

Very well done.

Task 3

1.

Explain the principles of permanent magnets including the distribution of magnetic fields.

Permanent magnets are structured from ferromagnetic materials such as iron, nickel or cobalt, these materials are used due to their unpaired electrons in their atoms. Permanent magnets generate its own persistent magnetic field as the unpaired electrons are always spinning creating their own magnetic field and will form together to create an individual magnetic domain having a north and south pole and with this the poles of each different domain will face in all different directions within the atom. With this an external magnetic field is applied to the raw material during manufacturing as its heated and cooled, this forces all the domains to align facing the direction of the external magnetic field. As the domains are pointing in the same direction it means that the whole permanent magnet is created with a preferred direction of magnetism of north to south pole. The north seeking pole and south seeking pole will attract and create a curved chain between the pole leading to the idea of lines of magnetic flux seen in figure 4. As Hughes states "The lines of magnetic flux are assumed to pass through the magnet, emerge from the N pole and return to the S pole" (Hughes, 2016 p. 137)

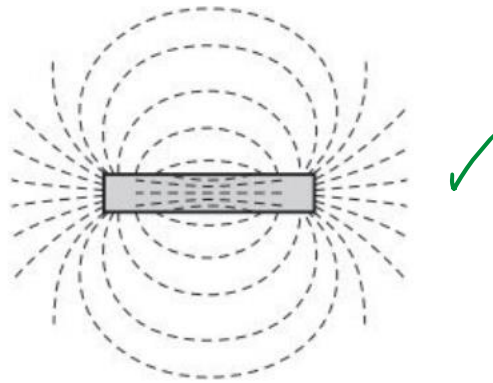


Figure 4- Lines of magnetic flux (Hughes, 2016 p. 137)

2.

a)

The maximum working flux density of a lifting electromagnet is 1.6T and the effective area of a pole face is circular in cross-section. If the total magnetic flux produced is 550mWb determine the radius of the pole face.

$$B = \frac{\phi}{A} \text{ Which can be rearranged for } A = \frac{\phi}{B}$$

$$A = \frac{0.5}{1.5} = 0.3333\text{m}^2 \quad \text{wrong numbers, correct method.}$$

$$A = \pi r^2 \text{ Which can be rearranged for } r = \sqrt{\frac{A}{\pi}} \quad \checkmark$$

$$r = \sqrt{\frac{0.3333}{\pi}}$$

$$r = 0.326\text{m} \quad \checkmark$$

b)

An iron toroid having a mean radius of 0.1m and cross-sectional area of 3.49cm² is wound with a 1200 turn coil. The coil current results in a flux of 0.2mWb in the toroid. Using the following data, determine (i) the coil current and (ii) the relative permeability of the toroid under these conditions.

H(At/m)	80	85	90	95	100
B(T)	0.5	0.55	0.58	0.59	0.6

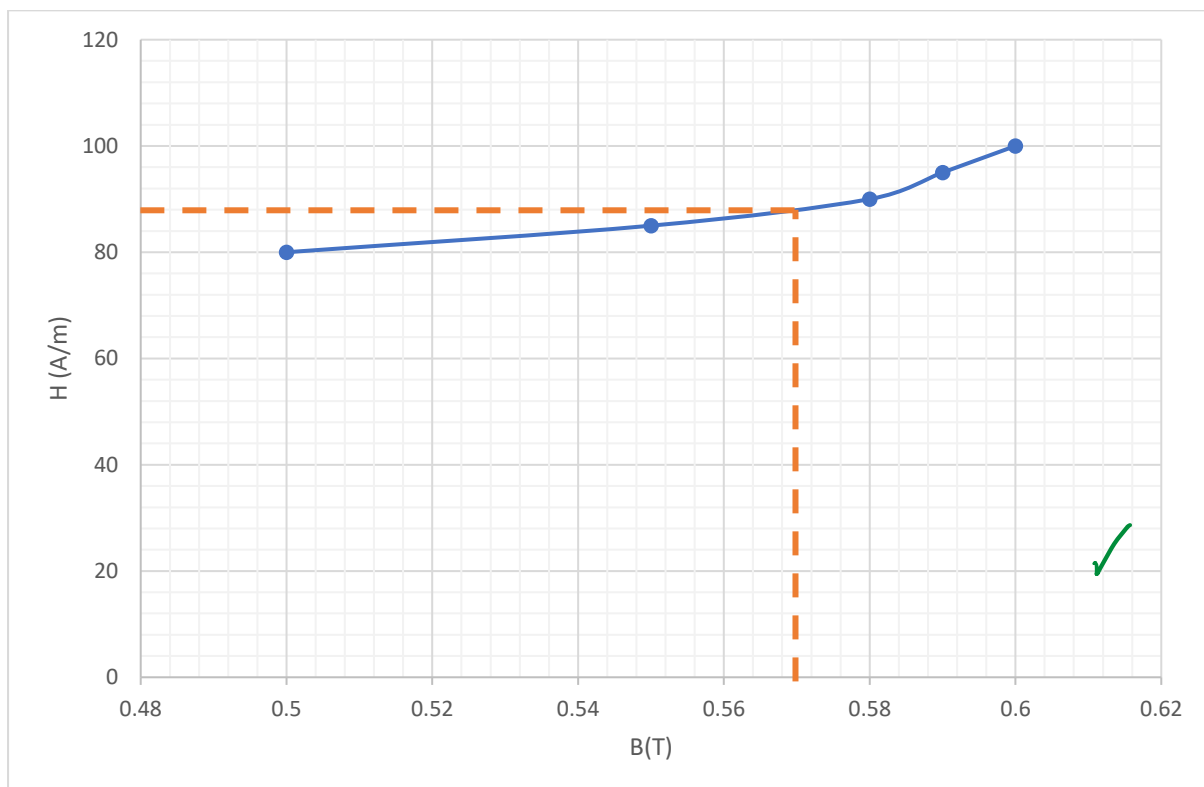


Figure 5 – B/H Graph from table

i)

$$A = 3.49 \text{ cm}^2 = 3.49 \times 10^{-4} \text{ m}^2 \quad \checkmark$$

$$B = \frac{\phi}{A} = \frac{0.2 \times 10^{-3}}{3.49 \times 10^{-4}} = 0.573 \text{ T} \quad \checkmark$$

Using this value for B against the graph, as seen in figure 5. H must equal 88 A/m. $\checkmark$

$$H = \frac{N \times I}{l} \text{ and } l = 2\pi r \quad \checkmark$$

$$l = 2 \times \pi \times 0.1 = 0.628 \text{ m}$$

$$I = \frac{lH}{N} = \frac{0.628 \times 88}{1200} \quad \checkmark$$

$$I = 46.05 \text{ mA} \quad \checkmark$$

ii)

$$\mu_0 \times \mu_r = \frac{B}{H} \text{ where } \mu_0 = 4\pi \times 10^{-7} \quad \checkmark$$

$$\mu_r = \frac{B}{\mu_0 \times H} = \frac{0.573}{(4\pi \times 10^{-7}) \times 88}$$

$$\mu_r = 5181.58 \quad \checkmark$$

well done.

3.

Explain the principle operation and construction of an electromagnet including the distribution of magnetic fields.

A basic electromagnet is constructed of a coil of insulated copper wire wrapped around an iron core while connected to a power source, as seen in figure 6. As the current is passed through the coil it will generate a magnetic field around it and thereby creating an electromagnet. $\checkmark$

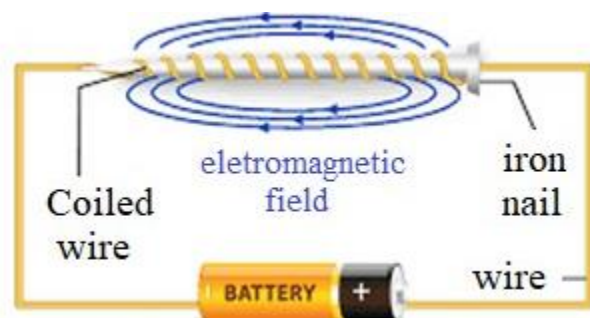


Figure 6- Construction of electromagnet (Anum, 2022) $\checkmark$

With the use of electromagnet Michael Faraday was able to prove electromagnetic induction which states, “The value of emf induced in a circuit or conductor is directly proportional to the rate of change of magnetic flux linking with it. The polarity of such an emf, induced by an increasing flux. Or opposite to that induced by a decreasing flux” (Wildi, 2013, p. 28). This means if a magnet is moved in and out of a coil of wire then an emf will be induced in the coil and causing a flow of current.

Faraday’s laws of electromagnetic induction also state, “The value of the induced voltage is proportional to the rate of change of flux” (Wildi, 2013, p. 28), which Wildi follows up with “When the flux inside a loop varies at the rate of 1 weber per second, a voltage of 1V is induced between the terminals.” (Wildi, 2012, p.28). This means if you have a coil of N turns and the flux is varied inside it, the voltage induced can be given by:

$$E = N \frac{\Delta \phi}{\Delta t}$$

Where;

E = induced voltage (V)

N = number of turns in the coil

$\Delta \phi$ = change of flux inside the coil (wb)

Δt = time interval during which the flux changes (s)

Figure 7 illustrates the magnetic field that is produced by an electromagnet when the coil of wire has an electric current passing through it, it will act like a magnet, however once the current is stopped it doesn’t. This is the difference between a permanent magnet and electromagnet as it can be turned on and off and is controlled by the current.

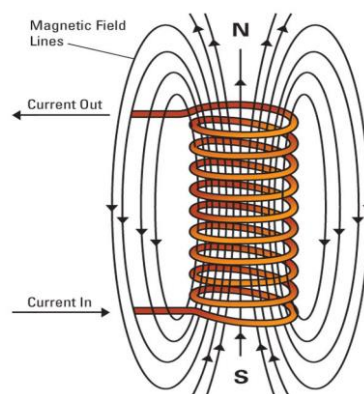


Figure 7- Magnetic field of an electromagnet (Magic of magnetism, 2022)

As an electromagnet uses an electrical current to create a magnetic field, due to this there are 3 ways you can altering the strength of an electromagnet, and these are to alter the values of the current or number of turns and by adding an iron core to increase the magnetic field. ✓

4.

A transformer is a device that uses some of the principles associated with magnetism. Explain the operation and construction of a transformer, include diagrams and equations to show how voltage, current and turn ratios are related. Discuss how transformers are an essential part of the National Grid System.

Hambley states that “A Transformer consists of several coils wound on a common core that usually consists of laminated iron (to reduce eddy-current loss).” (Allan R. Hambley, 2013, p.749). The transformer will transfer electric energy from one alternating current circuit to one or more other circuits, this process can be done to either increase or decrease the voltage, also known as step up and step-down transformers. ✓

Electromagnetic induction is used to let this process happen and works by passing a current through the primary coil and making the magnetic lines of force (flux lines) build up and collapse. This will mean the current is induced into the other coil also known as the secondary coil. ✓

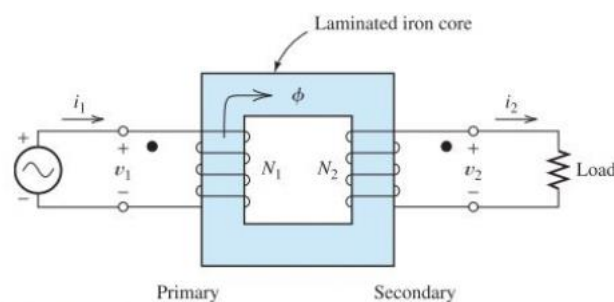


Figure 8- Basic transformer illustration (Hambley, 2013, p. 750)

Looking at figure 8 you will find a basic transformer illustrated, an ac voltage is connected to the primary coil that will have a certain number of turns of wire depending on the transformer (N_1). When the current flows into this coil it causes an ac magnetic flux around the core and will induce a voltage into the secondary coil (N_2). This will produce a power to the load. This secondary voltage is calculated by

multiplying the primary voltage by the ratio of the number of turns in the secondary coil to the number of turns in the primary coil, shown by rearranging the equation below:

$$\frac{\text{Voltage in Secondary Coil}}{\text{Voltage in Primary Coil}} = \frac{\text{Turns on Secondary Coil}}{\text{Turns on Primary Coil}}$$

OR

$$\frac{V_2}{V_1} = \frac{N_2}{N_1}$$

Using the equation above the voltage on the secondary coil can be shown as:

$$V_2 = \frac{N_2}{N_1} V_1$$

Whether the transformer is a step up or step down transformer will “Depend on the turns ratio N_2/N_1 , the rms secondary voltage can be greater or less than the rms primary voltage.” (Allan R. Hambley, 2013, p.749).

Considering the transformer in figure 8 the currents I_1 and I_2 produce opposing magnetic fields due to I_1 enters a dotted terminal and I_2 leaves a dotted terminal. The equation for current in a transformer can be identified as:

$$I_2 = \frac{N_1}{N_2} I_1$$

Comparing the voltage equation and the current equation, Hambley states that “if the voltage is stepped up (i.e. $N_2/N_1 > 1$) the current is stepped down, and vice versa.” (Allan R. Hambley, 2013, p.751).

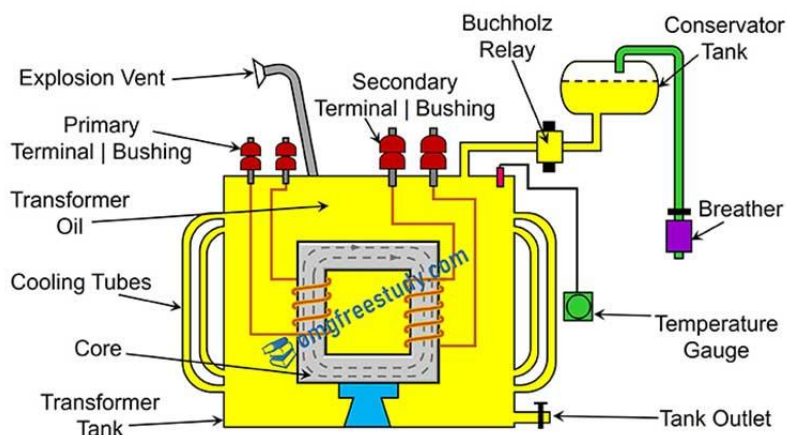


Figure 9- Construction of a transformer

Only one part of this is the transformer.

Figure 9 illustrates the construction of a transformer; both step up and step down consist of the same components however the primary and secondary coils will be swapped over. You will see that the transformer is made up from two inductive windings and a laminated steel core for the electromagnetic induction to work, it will also consist of suitable bushings to take out the terminals and oil conservator to provide oil in the transformer tank for cooling purposes. ✓

The main application for the transformer is to work along the electric distribution chain as seen in figure 10. Transformers are used in the national grid to do 2 things, these are to step up voltage while decreasing current and vice versa. These are known as step-up transformers and step-down transformers and they are used for different reasons. As you can see in figure 10 the power station will usually produce 25kV which will then be converted to 400kV by the step up transformer ready to travel along the power lines to the next stage of the distribution line. The step-up transformer will do this so the current is decreased for travel as this means that there will be less energy loss through the heating of the cables. It also allows the power lines to be smaller as less current is traveling through it allowing them to be above on pylons instead of underground. Once getting to where the supply needs to go it will be stepped-down by a transformer as seen in the diagram, this is so it can then be distributed at the correct voltages for the application within the sub station. The transformer will step it down from 400kV back to a lower voltage and higher current such as 132kV, 25kV or 11kV. If the grid was going to an industrial place like a factory or refinery the step-down transformer may only take it down to 11kV as they will have machinery needing higher voltage to run. However for domestic places like homes, school or shops it will be stepped down to 230V to make it safer as these places do not need high voltage. ✓

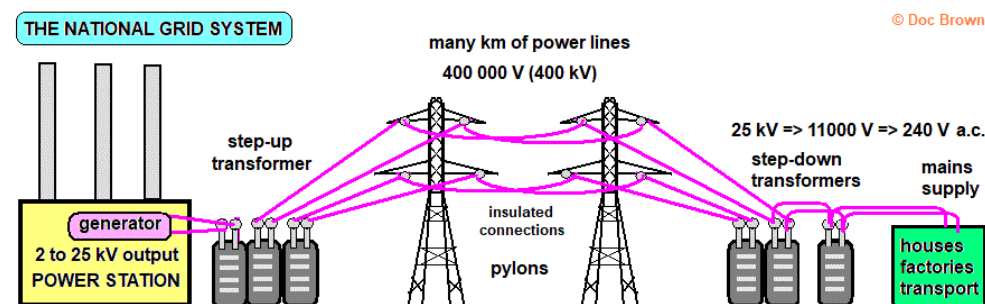


Figure 10- Transformers in the national grid

5.

Solve the following problems:

a)

An iron ring of cross-sectional area 8.4cm^2 and mean diameter 25cm , contains an air gap 3mm wide. It is required to produce a flux of 1.4mWb in the air gap. Calculate the mmf required, given that the relative permeability of the iron is 1200 under these operating conditions.

$$A = 8.4\text{cm}^2 = 8.4 \times 10^{-4}\text{m}^2$$

$$d = 25\text{cm} = 0.25\text{m}$$

$$\text{Air Gap} = 3\text{mm} = 3 \times 10^{-3}\text{m}$$

For Iron-

$$S_i = \frac{l_{\text{iron}}}{\mu_0 \mu_r A} \text{ where } l_{\text{iron}} = \pi d$$

$$S_i = \frac{0.25 \times \pi}{(4\pi \times 10^{-7}) \times 1200 \times 8.4 \times 10^{-4}}$$

$$S_i = 0.6200 \times 10^6 \text{ A/Wb}$$

For Air

$$S_a = \frac{l_{\text{air}}}{\mu_0 \mu_r A} \text{ where } l_{\text{air}} = \text{air gap}$$

$$S_a = \frac{3 \times 10^{-3}}{(4\pi \times 10^{-7}) \times 1 \times 8.4 \times 10^{-4}}$$

$$S_a = 2.8421 \times 10^6 \text{ A/Wb}$$

Total

$$S = S_i + S_a = 0.6200 \times 10^6 + 2.841 \times 10^6$$

$$S = 3.461 \times 10^6 \text{ A/Wb}$$

$$S = \frac{\text{mmf}}{\phi} \text{ which can be rearranged to } \text{mmf} = S\phi$$

$$\text{mmf} = 3.461 \times 10^6 \times 1.4 \times 10^{-3}$$

$$\text{mmf} = 4845.4 \text{ At}$$

well done.

b)

A rectangular coil of sides 10cm and 6cm is rotated in a magnetic field of flux density 1.2T, the longer side of the coil actually cutting this flux. The coil is made up of 80 turns and rotates at 1200rev/min. (i) Calculate the maximum generated e.m.f. (ii) If the coil generates 100V, at what speed will the coil rotate?

$$emf, E = 2BlvN \text{ where } v = \omega r$$

$$\omega r = \frac{nr}{60} \times 2\pi \times \frac{6 \times 10^{-2}}{2} = \frac{1200}{60} \times 2\pi \times \frac{6 \times 10^{-2}}{2}$$

$$v = 3.77m/s$$

i)

$$E = 2 \times 1.2 \times 10 \times 10^{-2} \times 3.77 \times 80$$

$$E = 72.384V$$

ii)

$$E = 100V$$

$$v = \frac{E}{2BlN} = \frac{100}{2 \times 1.2 \times 10 \times 10^{-2} \times 80}$$

$$v = 5.208m/s$$

$$\omega = \frac{v}{r} = \frac{5.208}{(6 \times 10^{-2} \div 2)}$$

$$\omega = 173.6rad/s$$

$$Speed = \frac{\omega \times 60}{2\pi} = \frac{173.6 \times 60}{2\pi}$$

$$Speed = 1657.76RPM$$

Excellent work.

Task 4

1.

Table 4 – Values for Task 4

Student Number	Oscilloscope Settings		Grid Spacing	
	Volts/Div	Timebase (ms/Div)	Vertical (peak to peak)	Horizontal (1 cycle)
4	5	20	5.4	4.6

$$V_{pp} = 5 \times 5.4 = 27V$$

$$T = 20 \times 4.6 = 92ms$$

Using the oscilloscope measurements for a sine wave stated in table 4 perform the following calculations

- Peak voltage
- Frequency
- Average voltage
- Root mean square (rms) voltage.

a)

$$V_p = V_m = \frac{V_p - p}{2} = \frac{27}{2}$$

$$V_p = 13.5V$$

b)

$$F = \frac{1}{T} = \frac{1}{92 \times 10^{-3}}$$

$$F = 10.87Hz$$

c)

$$V_{av} = 0.637 \times V_m = 0.637 \times 13.5$$

$$V_{av} = 8.60V$$

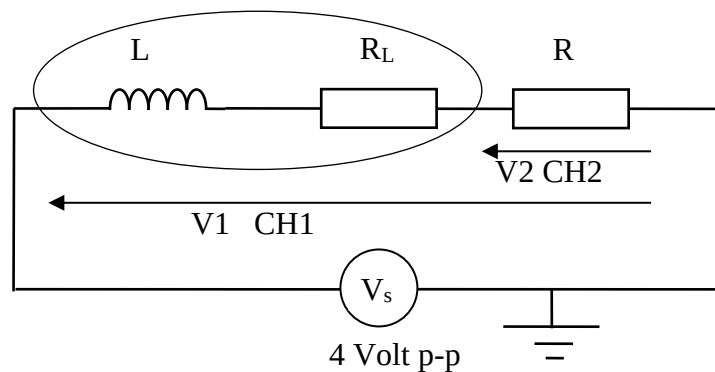
d)

$$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{13.5}{\sqrt{2}}$$

$$V_{rms} = 9.55V$$

2.

Below is a RL circuit:



Using the diagram above, the RL circuit was constructed.

3.

Measure and record the value of each of the component.

The values of each component was measurend and recorded below.

$$L = 2.21 \quad R = 26.7\Omega \quad R_L = 3.97\Omega \quad \checkmark$$

4.

Produce a table of measurements as shown below:

The table was completed and filled out with the measurements, shown below.

Table 5 – Measured results

Frequency (f) (kHz)	CH1 (V) <i>pk to pk</i> Voltage	CH2 (V) <i>pk to pk</i> Voltage	Time Difference (between peaks) (μs)	Phase Angle ($^{\circ}$)
1	1.68	1.32	68	24.48
2	2	1.3	60	43.2
3	2.32	1.22	50	54
4	2.62	1.12	42	60.48
5	2.86	1.02	37	66.6
6	3.08	0.96	32	69.12
7	3.26	0.9	29	73.08
8	3.38	0.84	26	74.88
9	3.48 $\checkmark$	0.76 $\checkmark$	24 $\checkmark$	77.76 $\checkmark$

5.

Produce a table of calculations as shown below:

The table was completed and filled out with the calculations, shown below.

Table 6 – Calculated results

Frequency (f - kHz)	X_L (Ω)	R_T	Z (Ω)	Current (A)	Phase Angle ($^\circ$)
1	13.89	30.67	33.67	0.119	24.36
2	27.77	30.67	41.38	0.097	42.16
3	41.66	30.67	51.73	0.077	53.64
4	55.54	30.67	63.45	0.063	61.09
5	69.43	30.67	75.9	0.053	66.17
6	83.32	30.67	88.78	0.045	69.79
7	97.2	30.67	101.92	0.039	72.49
8	111.09	30.67	115.24	0.035	74.57
9	124.97 ✓	30.67 ✓	128.68 ✓	0.031 ✓	76.21 ✓

Example of calculated results-

$$L = 2.21 \quad R = 26.7\Omega \quad R_L = 3.97\Omega$$

$$X_L = 2\pi fL = 2 \times \pi \times 1 \times 2.21 \quad \checkmark$$

$$X_L = 13.89\Omega \quad \checkmark$$

$$R_T = R + R_L = 26.7 + 3.97 \quad \checkmark$$

$$R_T = 30.67\Omega \quad \checkmark$$

$$Z = \sqrt{R_T^2 + X_L^2} = \sqrt{30.67^2 + 13.89^2} \quad \checkmark$$

$$Z = 33.67\Omega \quad \checkmark$$

$$I = \frac{V}{Z} = \frac{4}{33.67} \quad \checkmark$$

$$I = 0.119A \quad \checkmark$$

$$\theta = \tan^{-1}\left(\frac{X_L}{R_T}\right) = \tan^{-1}\left(\frac{13.89}{30.67}\right) \quad \checkmark$$

$$\theta = 24.36^\circ \quad \checkmark$$

Excellent work.

6.

Comment on the practical and calculation results, discussing any variations when comparing these results.

Looking at the calculated results compared to the practical results there are slight variations with the phase angle results, and this could be down to many factors. Firstly, from the testing equipment of the multimeter with how accurate it is and with the leads they could have bad continuity if they are dirty and causing poor contact. Another factor that could affect the results is human error, this can affect the calculated and the practical results. Rounding the calculation results can affect the outcome as you can be using rounded numbers to work out further results. Human error can also affect the practical results when using the oscilloscope will be how accurate the user is with the curser. Staying with the oscilloscope there can be a resolution error as there is a limited number of pixels on the screen so can affect how accurate the results are on the screen. ✓

Reference List

Anum. (2022). *Electromagnet: Construction, Working and Applications*. [Online].

Embibe. Available at: <https://www.embibe.com/exams/electromagnet/> [Accessed 11 January 2023].

Bakshi, U. A. (2009). *Basic Electrical Engineering*. 2nd ed. India: Technical Publications Pune. pp.2-23.

Brown. (2022). *Electricity Part 6 Generating electricity 'National Grid' power supply*. [Online]. docbrown. Available at: <https://docbrown.info/ephysics/electricity6.htm> [Accessed 11 January 2023].

Hambley, Allan R. (2013). *Electrical Engineering*. 6th ed. Essex: Pearson Education Limited. pp.749-755.

Hambley, Allan R. (2013). *Electrical Engineering*. 6th ed. Essex: Pearson Education Limited. pp.756-757.

Hughes, E. (2016). *Hughes Electrical and Electronic Technology*. 12th ed. Essex: Pearson Education Limited. pp.102-103.

Magic of Magnetism. (2022). *Electromagnets*. [Online]. North Eastern. Available at: [https://ece.northeastern.edu/fac-ece/nian/mom/electromagnets.html#:~:text=Moving%20charges%20create%20magnetic%20fields](https://ece.northeastern.edu/fac-ece/nian/mom/electromagnets.html#:~:text=Moving%20charges%20create%20magnetic%20fields,~:text=Moving%20charges%20create%20magnetic%20fields) [Accessed 11 January 2023].

Physics and Radio Electronics. (2015). *Capacitor*. [Online]. Physics and Radio Electronics. Available at: [https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/passive-components/cap](https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/passive-components/capacitor.html) [Accessed 11 January 2023].

Tajne, Er. Roshan. (2021). *Construction of Transformer | Transformer Parts and its Function*. [Online]. omgfreestudy. Available at:

<https://omgfreestudy.com/construction-of-transformer-and-transformer-parts/>
[Accessed 11 January 2023].

Wildi, T. (2013). *Electrical machines, drives, and power systems*. 6th ed. Essex: Pearson Education Limited. pp.23-24.

Wildi, T. (2013). *Electrical machines, drives, and power systems*. 6th ed. Essex: Pearson Education Limited. pp.27-28.

✓ Only need to state
the book once.

Bibliography

Bird, J. (2017). *Electrical and Electronic Principles and Technology*. 6th ed. London: Routledge.

Bird, J. (2017). *Electrical Circuit Theory and Technology*. 6th ed. London: Routledge. ✓