

LEVEL 4 ASSESSMENT SPECIFICATION

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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	9.9
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	22.2
Task 1 achieved 69%. Task 2 achieved 74%, Task 3 achieved 78%. Task 4 achieved 75%. Excellent knowledge and understanding of the basic underlying concepts and principles of the subject. Showed excellent understanding the calculated requirements. The research work was very good that used a variety of source material.		
3. Cognitive and Intellectual Skills	10	5.3
Task 1 achieved 57%. Task 4 achieved 48%. Good evaluation of the underlying concepts and principles for Task 1 and 4.		
4. Practical Application Skills	35	29.2
Task 1 achieved 85%. 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	6.6
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%)		

Assignment 1: Electrical Principles

Programme: HNC Electrical and Electronic Engineering

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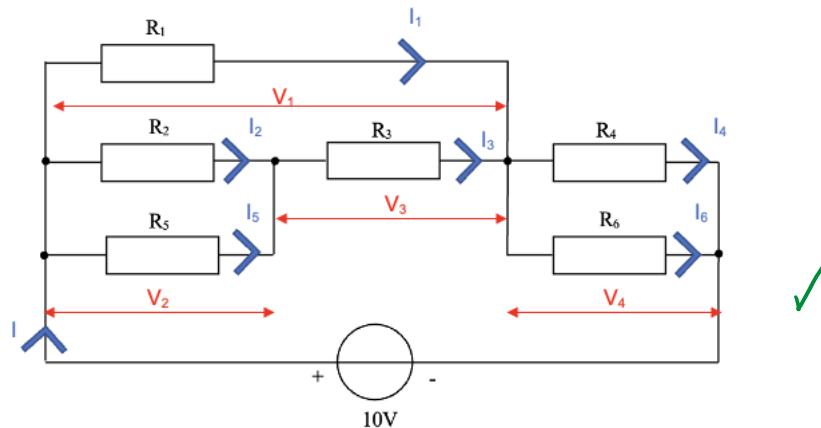
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Task 1-DC Circuits

1.) DC Circuit construction

The circuit shown below was constructed in class by using a breadboard and resistors. The total (R_T) was measured before connecting the power supply.



$R_1=4.7K\ \Omega$	$R_2=330\Omega$	$R_3=220\Omega$	$R_4=560\Omega$	$R_5=180\Omega$	$R_6=680\Omega$
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2.) Practical results

The circuit shown above was built with a breadboard and resistors which was connected to a 10V supply. The results obtained from the circuit are shown in the table below.

Voltage (V)	Current (mA)	Resistance (ohms)
$V_1=5.14$ ✓	$I_1=1.05$ ✓	$R_T=625$ ✓
$V_2=1.78$ ✓	$I_2=5.34$ ✓	
$V_3=3.35$ ✓	$I_3=15.10$ ✓	
$V_4=4.87$ ✓	$I_4=8.77$ ✓	
$V_5=1.78$ ✓	$I_5=9.73$ ✓	
$V_6=4.87$ ✓	$I_6=7.23$ ✓	
	$I=16.07$ ✓	

Good set of results

3.) Calculations

All the formulas and workings used to find 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.

Are listed below.

Total Resistance

$$R_{25} = \frac{R_2 \times R_5}{R_2 + R_5} = \frac{330 \times 180}{330 + 180} = \underline{116.47\Omega}$$

$$R_{235} = R_{25} + R_3 = 116.47 + 220 = \underline{336.47\Omega}$$

$$R_{1235} = \frac{R_1 \times R_{235}}{R_1 + R_{235}} = \frac{4700 \times 336.47}{4700 + 336.47} = \underline{313.99\Omega}$$

$$R_{46} = \frac{R_4 \times R_6}{R_4 + R_6} = \frac{560 \times 680}{560 + 680} = \underline{307.10\Omega}$$

$$R_T = R_{1235} + R_{46} = 313.99 + 307.10 = \underline{621.09\Omega}$$

Supply Current

$$I = \frac{V}{R_T} = \frac{10}{621.09} = \underline{16.10\text{mA}}$$

$$V_4 = I \times R_{46} = 16.1 \times 10^{-3} \times 307.10 = \underline{4.94\text{V}}$$

$$I_4 = \frac{V_4}{R_4} = \frac{4.94}{560} = \underline{8.82\text{mA}}$$

$$I_6 = \frac{V_4}{R_6} = \frac{4.94}{680} = \underline{7.26\text{mA}}$$

$$V_1 = V - V_4 = 10 - 4.94 = \underline{5.06\text{V}}$$

$$I_1 = \frac{V_1}{R_1} = \frac{5.06}{4700} = \underline{\underline{1.08\text{mA}}}$$

$$I_3 = I - I_1 = 16.1 \times 10^{-3} - 1.08 \times 10^{-3} = \underline{\underline{15.02\text{mA}}}$$

$$V_3 = I_3 \times R_3 = 15.02 \times 10^{-3} \times 220 = \underline{\underline{3.3\text{V}}}$$

$$V_2 = V_1 - V_3 = 5.06 - 3.3 = \underline{\underline{1.76\text{V}}}$$

$$I_2 = \frac{V_2}{R_2} = \frac{1.76}{330} = \underline{\underline{5.33\text{mA}}}$$

$$I_5 = \frac{V_2}{R_5} = \frac{1.76}{180} = \underline{\underline{9.78\text{mA}}}$$

Power

$$P_1 = I_1 \times V_1 = 1.08 \times 10^{-3} \times 5.06 = \underline{\underline{5.46\text{mW}}}$$

$$P_2 = I_2 \times V_2 = 5.33 \times 10^{-3} \times 1.76 = \underline{\underline{9.38\text{mW}}}$$

$$P_3 = I_3 \times V_3 = 15.02 \times 10^{-3} \times 3.3 = \underline{\underline{49.57\text{mW}}}$$

$$P_4 = I_4 \times V_4 = 8.82 \times 10^{-3} \times 4.94 = \underline{\underline{43.57\text{mW}}}$$

$$P_5 = I_5 \times V_5 = 9.78 \times 10^{-3} \times 1.76 = \underline{\underline{17.18\text{mW}}}$$

$$P_6 = I_6 \times V_6 = 7.26 \times 10^{-3} \times 4.94 = \underline{\underline{35.86\text{mW}}}$$

Excellent work, well done.

Test Results

Voltage (V)	Current (mA)	Resistance (ohms)
V1=5.14	I1=1.05	RT=625
V2=1.78	I2=5.34	
V3=3.35	I3=15.10	
V4=4.87	I4=8.77	
V5=1.78	I5=9.73	
V6=4.87	I6=7.23	
	I=16.07	

Calculated results

Voltage (V)	Current (mA)	Resistance (ohms)
V1=5.06	I1=1.08	RT=621.09
V2=1.76	I2=5.33	
V3=3.3	I3=15.02	
V4=4.94	I4=8.82	
V5=1.76	I5=9.78	
V6=4.94	I6=7.26	
	I=16.10	

4.) Comments on practical and calculated result

The information below comments on the variations between the practical and calculated results also referring to relative theories such as Kirchhoff's laws and how the results relate.

When comparing the practical results with the calculated results there are some slight variations for example the resistance total was calculated to be 621.09 but was found to be 625 in the practical. There are many factors which can cause these small variations between the practical and calculated results.

The first factor which causes a variation is the resistors having a tolerance of + or – 5%. In the circuit R3 is 220Ω when finding the calculations whereas with the tolerance R3 it could range from 209-231Ω which slightly variates the expected results. Another factor which can variate the results is human error. When calculating the results human error is applied by rounding the answers to 2 decimal places. 

Another main factor which causes a variation with the results is the multimeters tolerance/calibration. The multimeter used for the testing had an internal resistance of 10 mega ohms. So, when measuring for current the readings may be slightly bigger due to the internal resistance. The resistance in parallel will vary the readings. The continuity of the leads if they are dirty can also affect the readings and if the contact of the leads onto the circuit isn't good it can affect the readings. ✓

When calculating the results for the circuit and checking the test results are correct Kirchhoff's current and voltage law are used. The current law is "*the total current flowing towards a junction is equal to the total current flowing from that junction, i.e., the algebraic sum of the currents at the junction is zero*". (Bolton, 2015) ✓

This is shown in the circuit above as I_2 and $I_5 = I_3$, I_1 and $I_3 = I$ as well as I_4 and $I_6 = I$. ✓
This is because the current across R_2 and R_5 in parallel are flowing to the junction R_3 meaning the current from those 2 resistors must add up to that junction. This can be seen in the calculations because if you add I_2 which is 5.33 and add it with I_5 which is 9.78 this adds up to around the I_3 value of 15.02mA. The value is slightly different due to rounding numbers to 2 D.P. The law can also be seen in the last 2 resistors in parallel in the circuit and calculation that the current flowing from R_4 and R_6 is equal to the supply current. This also means that the currents from R_1 and R_3 would also equal the supply current as the current from them resistors join up on the circuit flowing into R_4 and R_6 . ✓

The voltage law is as stated "*in a closed loop circuit or loop, the algebraic sum of the potential differences across each part of the circuit is equal to the applied e.m.f.*". (Bolton, 2015)

How does it apply to your results ?

Task 2-Capacitors

1.) Capacitors construction and methods used to alter its value

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.

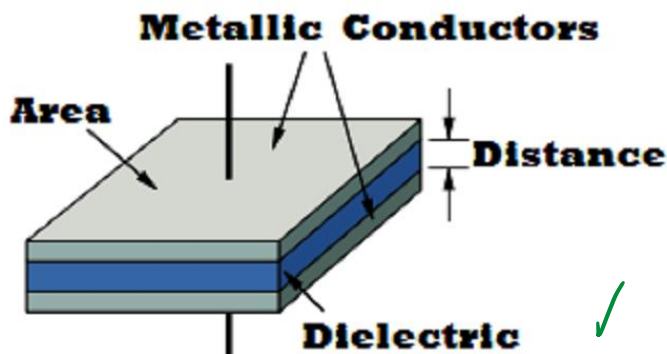


Figure 1- Capacitor construction (Bilal, 2020)

An electrical device which stores electrical charge is known as a capacitor. The construction for a capacitor is made from two sheets of conducting plates which are normally metallic separated by a thin layer of insulating material as shown in figure 1. The insulating material separating the two plates is known as a dielectric. The dielectric can

be materials such as polyester, polypropylene, mica and air etc. ✓

Capacitors are used in a variety of electronic applications where different capacitor values are needed. The capacitance can be altered by the area, distance between the plates and the dielectrics ability to support the electrostatic forces. The capacitor value can be altered by changing the dielectric material as it changes the support to electrostatic forces. When the dielectric constant gets greater the ability to support the electrostatic forces increases. Therefore, when the dielectric constant increase so do the capacitance. ✓

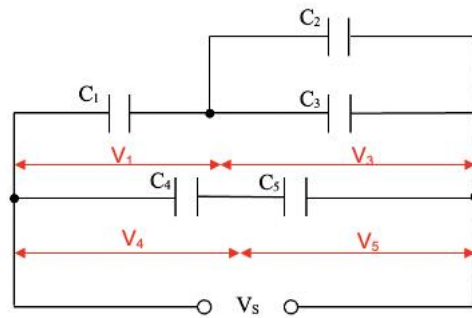
By connecting two capacitors in parallel this doubles the area of each plate which then “we may therefore say that the capacitance of a capacitor is proportional to the area of each plate.” (Hughes, 2016) ✓

Whereas if the thickness of the distance is doubled this will make the capacitor value lower meaning that “the capacitance of a capacitor is inversely proportional to the distance between the plates; and the above relationship may be summarised ✓

thus: $\text{Capacitance} \propto \frac{\text{Area of plates}}{\text{distance between plates}}$.” (Hughes, 2016) ✓

Therefore, from the quotes above it can be seen that when the area of the plates increase, and the distance of the plates decrease the capacitance increases. ✓

2.) Circuit with capacitors in series/parallel to a dc voltage source



C1	C2	C3	C4	C5	Vs
22 μF	15 μF	39 μF	33 μF	22 μF	15 V

The values above are used to 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.

The equivalent circuit capacitance

$$C_{23} = C_2 + C_3 = 15 + 39 = \underline{54 \mu\text{F}}$$

$$C_{123} = \frac{C_1 \times C_{23}}{C_1 + C_{23}} = \frac{22 \times 54}{22 + 54} = \frac{1188}{76} = \underline{15.63 \mu\text{F}}$$

$$C_{45} = \frac{C_4 \times C_5}{C_4 + C_5} = \frac{33 \times 22}{33 + 22} = \frac{726}{55} = \underline{13.2 \mu\text{F}}$$

$$C_T = C_{123} + C_{45} = 15.63 + 13.2 = \underline{28.83 \mu\text{F}}$$

Total charge

$$Q_T = C_T \times V = 28.83 \times 15 = \underline{432.45 \mu\text{C}}$$

The charge in each capacitor

$$Q_4 = Q_5 = C_{45} \times V = 13.2 \times 15 = \underline{198\mu\text{C}}$$

$$Q_1 = Q_T - Q_{45} = 432.45 - 198 = \underline{234.45\mu\text{C}}$$

$$V_1 = \frac{Q_1}{C_1} = \frac{234.45}{22} = \underline{10.66\text{V}}$$

$$V_2 = V_3 = V - V_1 = 15 - 10.66 = \underline{4.34\text{V}}$$

$$Q_2 = C_2 \times V_3 = 15 \times 4.34 = \underline{65.10\mu\text{C}}$$

$$Q_3 = C_3 \times V_3 = 39 \times 4.34 = \underline{169.26\mu\text{C}}$$

The energy stored in each capacitor

$$W_1 = \frac{1}{2} C_1 \times V_1^2 = \frac{1}{2} \times 22 \times 10.66^2 = \underline{1249.99\mu\text{J}} = 1.25\text{mJ}$$

$$W_2 = \frac{1}{2} C_2 \times V_3^2 = \frac{1}{2} \times 15 \times 4.34^2 = \underline{141.27\mu\text{J}}$$

$$W_3 = \frac{1}{2} C_3 \times V_3^2 = \frac{1}{2} \times 39 \times 4.34^2 = \underline{368.29\mu\text{J}}$$

$$V_4 = \frac{Q_4}{C_4} = \frac{198}{33} = \underline{6\text{V}}$$

$$V_5 = \frac{Q_5}{C_5} = \frac{198}{22} = \underline{9\text{V}}$$

$$W_4 = \frac{1}{2} C_4 \times V_4^2 = \frac{1}{2} \times 33 \times 6^2 = \underline{594\mu\text{J}}$$

$$W_5 = \frac{1}{2} C_5 \times V_5^2 = \frac{1}{2} \times 22 \times 9^2 = \underline{891\mu\text{J}}$$

The total energy stored in the circuit

$$W_T = \frac{1}{2} C_T \times V^2 = \frac{1}{2} \times 28.83 \times 15^2 = \underline{3243.38\mu\text{J}}$$

Task 3-Magnetism

1.) Permanent magnets

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

As stated in (Hannahs, 2022) *“Permanent magnets are materials where the magnetic field is generated by the internal structure of the material itself”*.

Permanent magnets are made from hard ferromagnetic materials such as alnico, samarium cobalt, ferrite, flexible rubber and neodymium magnets. All these materials produce a naturally occurring albeit weak, magnetic field which is produced by electrons surrounding the nuclei of their atoms. ✓

Each permanent magnet has its own north and south pole. When the magnet is not magnetised, its fields point in any direction and the magnetic fields cancel each other out. Permanent magnets are made from ferromagnetic material heated to a very high temperature whilst being exposed to a strong external field. This makes the individual magnetic field to the point when all fields are aligned and the material reaches its magnetic saturation point. It is then cooled and the fields are locked in position. (First4magnets, 2023) ✓

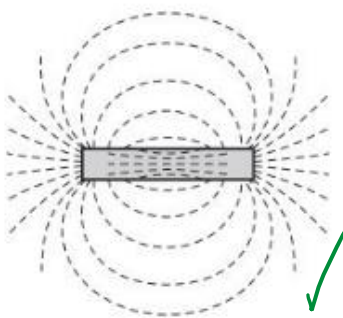


Figure 2- Permanent magnet distribution of magnetic fields (Hughes, 2016)

Michael Faraday produced a way of visualizing the distribution and density of a magnetic field. This was done by placing a permanent magnet on a table and place a sheet of cardboard over it which you then sprinkle steel filings uniformly over the sheet. You then slightly tap the cardboard causing the filings to set themselves in curved chains between the poles as shown in figure 2. (Hughes, 2016) ✓

2.A) Calculations

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.

$$B=1.6\text{T}$$

$$\Phi=550\text{mWb}=0.55\text{Wb}$$

$$B = \frac{\Phi}{A} = A = \frac{\Phi}{B} \quad \checkmark$$

$$A = \frac{0.55}{1.6} = 0.34\text{m}^2 \quad \checkmark$$

$$A = \pi r^2 = r^2 = \frac{A}{\pi} = r = \sqrt{\frac{A}{\pi}} \quad \checkmark$$

$$r = \sqrt{\frac{0.34}{\pi}} = \underline{\underline{0.329\text{m}}} \quad \checkmark$$

2.B) Calculations

An iron toroid having a mean radius of 0.1m and cross-sectional area of 3.49cm^2 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.

$$A = 3.49\text{cm}^2$$

$$A = 3.49 \times 10^{-4}$$

I.)

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

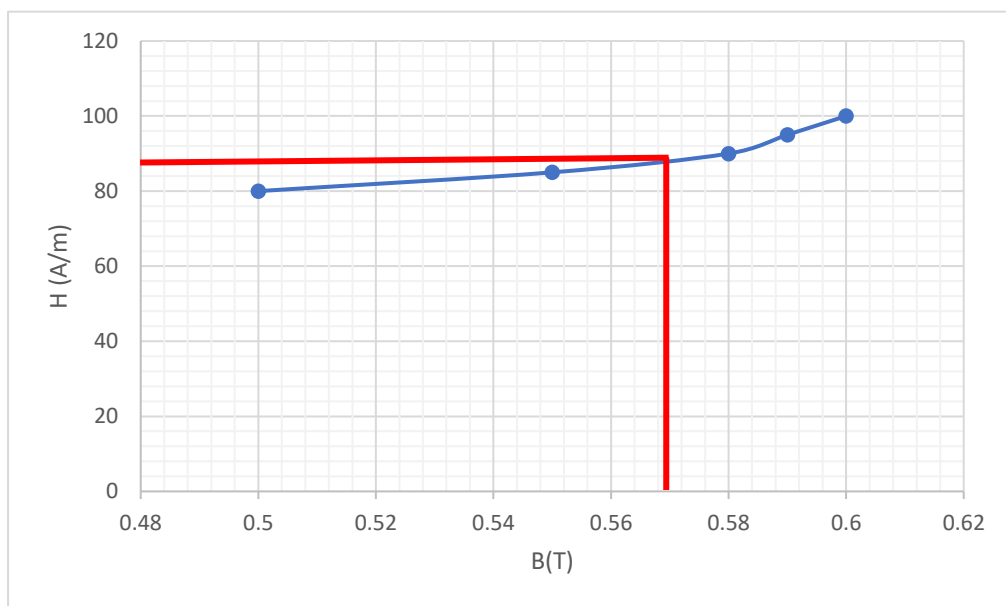


Figure 3-BH graph

From using the BH graph the value $H = 88\text{A/m}$

$$H = \frac{N \times I}{L}$$

$$L = 2\pi r$$

$$L = 2 \times \pi \times 0.1 = 0.63\text{m}$$

$$I = \frac{L \times H}{N} = I = \frac{0.63 \times 88}{1200} = \underline{\underline{0.046\text{ A}}}$$

II.)

$$\mu_0 \times \mu_r = \frac{B}{H}$$

$$\mu_r = \frac{B}{\mu_0 \times H} = \frac{0.573}{4 \times \pi \times 10^{-7} \times 88} = 5181.58$$

$$\underline{\underline{\mu_r = 5181.58}}$$

3.) Electromagnets

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

Electromagnets are made from winding coils of wire such as copper around a soft iron core in the shape of a U or a solenoid with electricity passing through them as shown in figure 4. When electricity is supplied to coils of wire moving charges are produced creating magnetic fields. This means that the coils in the electromagnet have an electric current passing through them resulting in the coils acting as a magnet. ✓

Faraday's first law states that *"Whenever a conductor is placed in a varying magnetic field an EMF gets induced across the conductor (called as induced emf), and if the conductor is a closed circuit then induced current flows through it"*. ✓

(Daware, 2021)

Electromagnets are different to permanent magnets because they are controlled by the flow of current and can be turned on and off as a magnet. This is because when the electricity stops flowing the coils don't act as a magnet anymore.

Faraday's second law states that *"the magnitude of induced emf is equal to the rate of change of flux linkages with the coil"*. (Daware, 2021) ✓

The strength of the magnetic field from the electromagnet can be increased by using a soft iron core, more turns of wire on the coil and lastly supplying more current. When an electromagnet is connected to a battery the core becomes magnetised which it then behaves like a permanent magnet. This is shown in figure 4 where the electromagnet magnetic fields are shown by the lines and the arrows showing the direction. The direction of the magnetic fields can be reversed by changing the direction of the current. ✓



Figure 4- Electromagnet
(Ece.northeastern.edu, 2022)

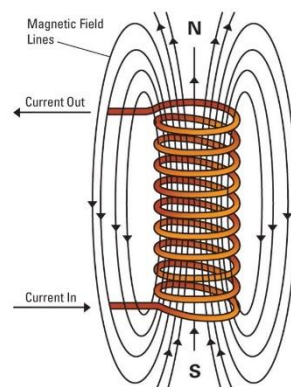


Figure 5- Electromagnet magnetic fields
(Ece.northeastern.edu, 2022)

4.) Transformers

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.

Working Principle of a Transformer

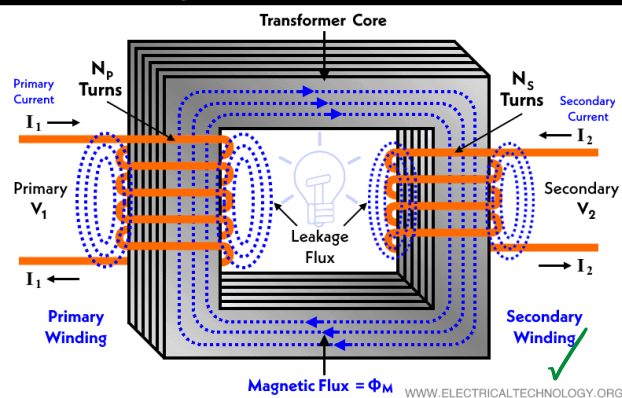


Figure 5- Transformer construction (Technology, 2022)

A transformer is a completely static solid electrical device used for adjusting AC voltages by either stepping them up or down depending on what is required. Transformers consist of coils which are made of insulated wire wound on a laminated steel core as shown in figure 5. The transformer primary coil magnetizes the iron core when voltage is introduced to one coil. When voltage is then induced in the other coil this is known as the secondary coil.

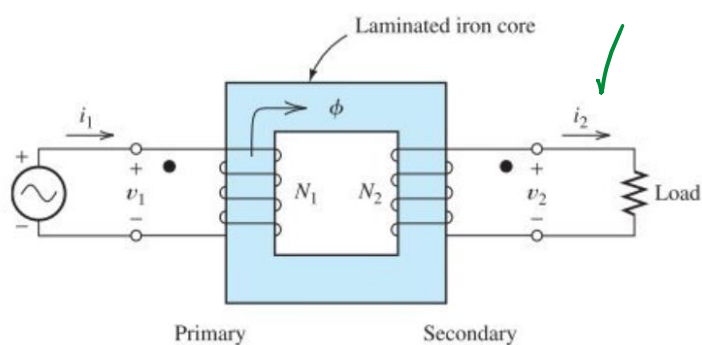


Figure 6- Transformer labelled for equation examples (Hambley, 2013)

The change of voltage between the primary and secondary relies on the turn's ratio of the two coils. The voltage across each winding is proportional to the amount of turns. The peak and rms values of the transformer voltages are also related by the turns ratio which the equation is shown as " $V_{2rms} = \frac{N_2}{N_1} V_{1rms}$ " in (Hambley, 2013).

These values from the equation can be seen in figure 6.

Figure 6 shows that the primary coil is connected to an ac voltage source which consist of N_1 turns of wire. An ac magnetic flux appears in the core from current flowing into the primary side. The flux then makes a voltage in the N_2 -turn secondary coil. This then delivers power to the load. The rms secondary voltage is either greater or less than the primary voltage depending on the turns ration N_2/N_1 . The primary voltage can be given by the formula of " $V_1(t) = V_{1m} \cos(\omega t)$ " (Hambley, 2013). Because all of the flux links with all of the turns the secondary voltage can be given by the formula of " $V_2(t) = \frac{N_2}{N_1} V_1(t)$ " (Hambley, 2013)

Figure 6 shows that the currents I_1 and I_2 produce opposing magnetic fields. This is shown on figure 6 where I_1 enters the dotted terminal which then I_2 leaves a dotted terminal. The formula for the Current ratio can be given by the formula of

" $V_2(t) = \frac{N_2}{N_1} V_1(t)$ " (Hambley, 2013). When comparing the voltage equation to the current equation you can tell that if the voltage is stepped up $N_2/N_1 > 1$ then the current is stepped down vice versa.

Transformers use a soft Iron core to facilitate low reluctance path for the flux linkage between primary and secondary windings. Reluctance in the magnetic circuit analogous the resistance in electric circuits which resists the generation of flux in the windings. Therefore, without the soft iron core, the flux linkage will be poor, and the output of the transformer will be reduced. Soft Iron core also possesses low retentivity and coercivity thereby reducing the hysteresis losses. Hysteresis loss is the heating of the core because of the internal molecular structure reversals which occur as the magnetic flux alternates. The iron core is divided into insulated laminations to reduce eddy currents. Eddy currents are produced from the voltage induced in the iron core causing eddy currents to flow giving a rise in the production of heat. By laminating the iron core this increases the resistance resulting in reducing the currents and associated loss.

Transformers are an essential part of the national grid system used to increase the voltage of electricity for transmission, and to reduce the voltage to lower levels for distribution by the networks of the local electricity companies. Firstly, as seen in figure 7 the power station will produce around 25KV which will then be stepped up by the transformer from 25KV to 400KV. The voltage is increased on the overhead lines to decrease the current so when the electricity travels distance on the overhead lines less energy will be lost through the heating of the wire. Just before the transmission lines reach a town or village a step-down transformer will be used in the grid network. The transformer is used in the grid network to step down the voltage from 400KV to 132KV which is then stepped down according to what is requires as shown in figure 7. The step-down transformer will turn the high voltage and low current into lower voltage and higher current. Before electricity is supplied to home, factories and shops the voltage will need to be stepped down to a safer voltage of 230V.

As stated, “Medium sized transformers have a full load efficiency of about 97-98 percent” (Hughes, 2016) meaning that the loss at each end of the transformations is very small. The statement shows how efficient and crucial transformers are in the national grid system. ✓

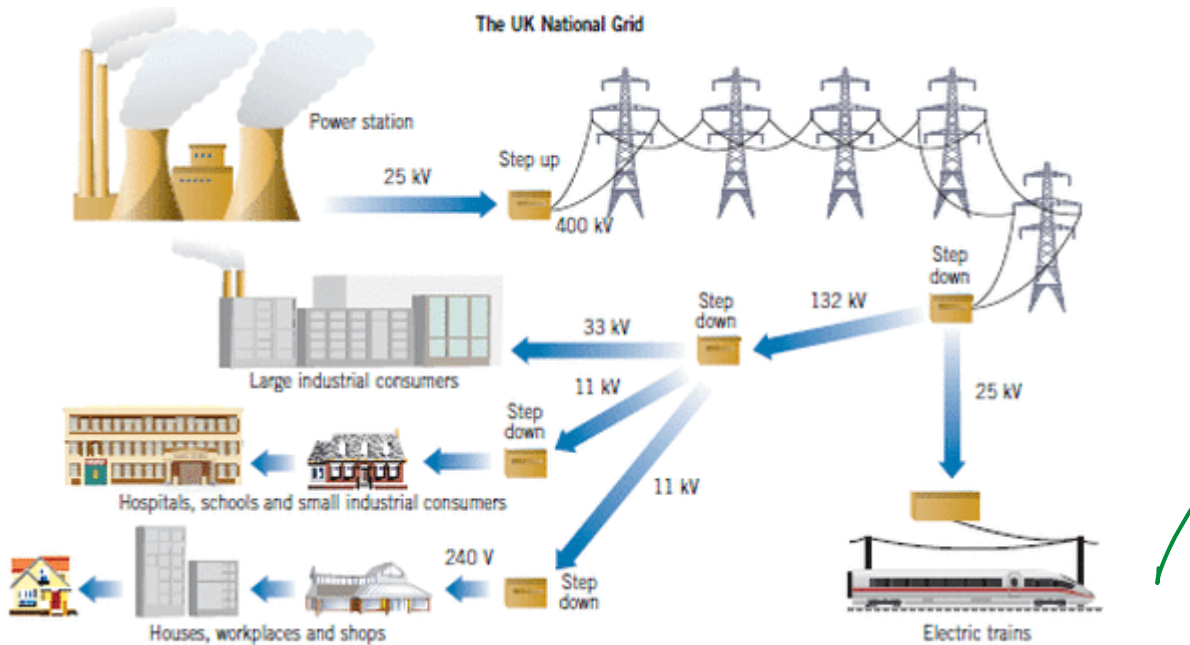


Figure 7- How transformers are used in the national grid (Site, 2022)

5.A) Calculations

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

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

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

Iron

$$S_i = \frac{L \times \mu_r \times \mu_0 \times M_r \times A}{L \times \text{Iron} = \pi d}$$

$$S_i = \frac{0.25 \times \pi}{4 \times \pi \times 10^{-7} \times 1200 \times 8.4 \times 10^{-4}} = 0.62 \times 10^6 \text{ A/wb}$$

Air

$$S_a = \frac{L \times a}{\mu_0 \times M_r \times A} = \frac{3 \times 10^{-3}}{4 \times \pi \times 10^{-7} \times 1200 \times 8.4 \times 10^{-4}} = 2.84 \times 10^6 \text{ A/wb}$$

$$\text{Total } S = S_i + S_a = 0.62 + 2.84 = 3.46 \times 10^6 \text{ A/wb}$$

$$S = \frac{mmf}{\phi} = mmf = S \times \phi = 3.46 \times 10^6 \times 1.4 \times 10^{-3} = 4844 \text{ At}$$

$$\text{mmf} = 4844 \text{ At}$$

5.B) Calculations

i)

$$\text{Emf, } E = 2 \times B \times L \times V \times N$$

$$V = W r = \frac{n r}{60} \times 2 \times \pi \times \frac{6 \times 10^{-2}}{2} = \frac{1200}{60} \times 2 \times \pi \times \frac{6 \times 10^{-2}}{2} = 3.77 \text{ m/s}$$

$$E = 2 \times 1.2 \times 10 \times 10^{-2} \times 80 \times 3.77 = 72.38 \text{ V}$$

$$\text{E} = 72.38 \text{ V}$$

ii)

$$E = 100 \text{ V}$$

$$V = \frac{E}{2 \times B \times L \times N} = E = \frac{100}{2 \times 1.2 \times 10 \times 10^{-2} \times 80} = 5.21 \text{ m/s}$$

$$W = \frac{V}{r} = \frac{5.21}{\frac{6 \times 10^{-2}}{2}} = 173.6 \text{ rad/s}$$

$$\text{Speed} = W \times \frac{60}{2\pi} = 173.6 \times \frac{60}{2\pi} = 1657.76 \text{ rev/min}$$

$$\text{Speed} = 1657.76 \text{ rev/min}$$

Very well done, have shown an excellent understanding

Task 4- AC circuits

1.) Sine wave oscilloscope measurements

Oscilloscope Settings		Grid Spacing	
Volts/Div	Timebase (ms/Div)	Vertical (peak to peak)	Horizontal (1 cycle)
0.5	20	7.8	4

1.A) Calculations

$$V_{PP} = 0.5 \times 7.8 = 3.9\text{V} \quad \checkmark$$

$$V_P = V_M = \frac{V_{PP}}{2} = \frac{3.9}{2} = \underline{\underline{1.95\text{ V}}} \quad \checkmark$$

1.B) Calculations

$$T = 20 \times 4 = 80\text{ms} \quad \checkmark$$

$$F = \frac{1}{T} = \frac{1}{80 \times 10^{-3}} = \underline{\underline{12.5\text{ Hz}}} \quad \checkmark$$

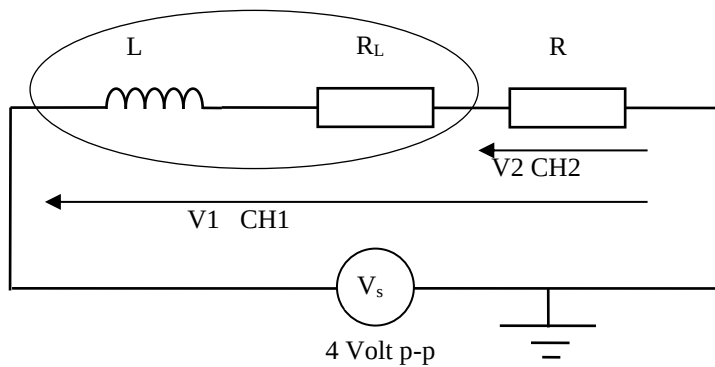
1.C) Calculations

$$A_V = 0.637 \times V_P = 0.637 \times 1.95 = \underline{\underline{1.24\text{ V}}} \quad \checkmark$$

1.D) Calculations

$$V_{RMS} = \frac{V_M}{\sqrt{2}} = \frac{1.95}{\sqrt{2}} = \underline{\underline{1.38\text{V}}} \quad \checkmark$$

2.) RL circuit



Shown above is a RL circuit which was constructed using breadboard.

3.) Recorded value of the components

$L=2.21\text{mH}$ $R= 26.7\Omega$, $R_L=3.97\Omega$, ✓

4.) Measured values

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 ✓	0.76 ✓	24 ✓	77.76 ✓

5.) Calculated values

Frequency (f - kHz)	$X_L (\Omega)$	R_T	$Z (\Omega)$	Current (A)	Phase Angle (°)
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

Examples of calculated results

Examples shown below for frequency 2-

$L=2.21\text{mH}$ $R=26.7\Omega$, $R_L=3.97\Omega$,

$$X_L = 2\pi fL = 2 \times \pi \times 2 \times 2.21 = \underline{27.77\Omega}$$

$$R_T = R + R_L = 26.7 + 3.97 = \underline{30.67\Omega}$$

$$Z = \sqrt{R_T^2 + X_L^2} = \sqrt{30.67^2 + 27.77^2} = \underline{41.37\Omega}$$

$$I = \frac{V}{Z} = \frac{4}{41.37} = \underline{0.097\text{A}}$$

$$\phi = \tan^{-1} \left(\frac{X_L}{R_T} \right) = \tan^{-1} \left(\frac{27.77}{30.67} \right) = \underline{42.16^\circ}$$

well done.

6.) Comments on the practical and calculated results

When comparing the practical and calculated results there are some variations due to some factors. Firstly, there could be small variations in the readings gained for the inductor and resistors in the RL circuit used to gain the result for the practical and calculations. When testing across the resistance in the circuit the multimeters internal resistance impacts the overall resistance of the circuit. Human error causes variations in the results due to rounding number up and down to 2 decimal places. Lastly the use of the oscilloscope can cause a variation in the results. This is because the cursor lines used on the waveform when measuring the time interval between 2 points is likely to be slightly wrong and is also rounded up to the nearest whole number on the oscilloscope causing very slight variations with the results. From the calculated results shown above you can see that when the current decreases the phase angle increases. The phase angle also has the relationship that when the frequency, inductive reactance and the impedance increases so does the phase angle. With the measured results shown above, when the frequency increases the peak-to-peak voltage on channel 1 increases whereas channel 2 decreases. The phase angle has the relationship with time that when the time difference between the peaks decreases the phase angle increases. ✓

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