

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Ben Hathaway	Student ID number:	
Programme:	HNC Electrical/Electronic Engineering, Power Systems Engineering & Instrumentation Engineering		
Module:	Electrical Principles		
Module code:	PCEE4001	Contribution to Overall Module Assessment (%):	100%
Lecturer:	Jason Pointer	Internal Verifier:	Steve Roberts
Assignment Title:	Electrical Principles	Word count (or equivalent):	2000
Submission deadline:	16/01/19	Return date of provisional marks & written feedback:	
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	9.3
Selection of relevant and credible sources, used a number of books and websites. Generally sound referencing, with no inaccuracies or inconsistencies but could have included a few more references.		
2. Knowledge and Understanding Skills	25	15
Task 1 achieved 78%. Task 2 achieved 56%. Task 3 achieved 50%. Task 4 achieved 55%. Knowledge of the basic underlying concepts and principles is accurate with a good understanding in most areas. There were errors in some the calculation work and need to be careful with units.		
3. Cognitive and Intellectual Skills	15	8.5
Task 1 achieved 62%. Task 4 achieved 52%. Good evaluation of the underlying concepts and principles but were a little bit limited in the evaluation of Task 4.		
4. Practical Application Skills	35	22.75
Task 1 achieved 70%. Task 4 achieved 60%. A very good 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
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)

Up to 1 week late (40% Max)
Over 1 week late (0%)

62%



ELECTRICAL PRINCIPLES

Ben Hathaway
Cape - 146378

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DC Circuits

Introduction

I constructed two different circuits to complete this task, one with three different resistors in series and one with three different resistors in parallel and took different measurements throughout to compare them to values I later calculated.

DC circuits are circuits that use direct current and direct voltage in which electric current flows in only one direction throughout the system. These types of circuits are used in mainly low voltage applications in which batteries are used for the power source. A DC waveform is a straight line when shown in graph format as shown below.

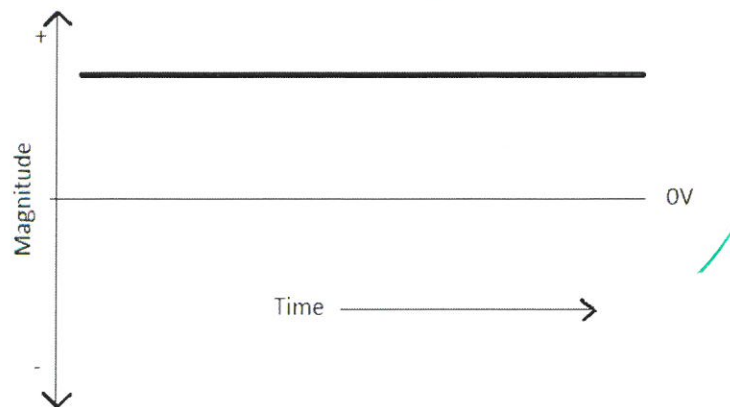
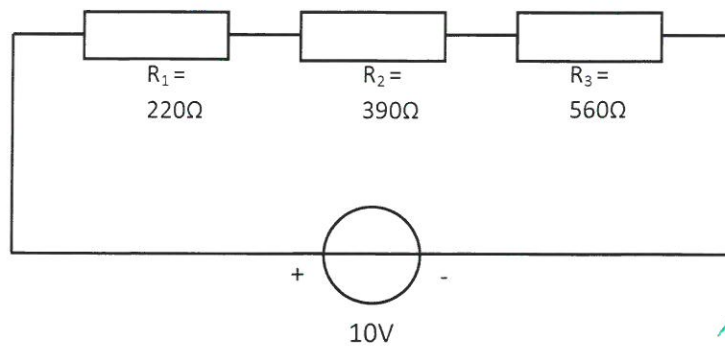


Figure 1a resistors in series



The circuit was constructed with the three resistors in series on a breadboard with the resistors values as shown in figure 1a. Before connecting the power supply the total resistance of the resistors was measured using a multimeter. The ten volt power source was then connected before measuring the p.d. value across each resistor and the supply current again using a multimeter.

The table below shows my measured values.

	Measured Values
Total resistance	1154Ω
Supply current	8.54mA
P.d across resistors	R ₁ = 1.84V R ₂ = 3.35V R ₃ = 4.80V

Calculations for resistors in series

Total resistance

$$R_t = R_1 + R_2 + R_3$$

$$R_t = 220\Omega + 390\Omega + 560\Omega$$

$$R_t = 1170\Omega$$

Supply current

$$I = \frac{V}{R_t}$$

$$I = \frac{10}{1170} = 8.54mA$$

p.d value across each resistor

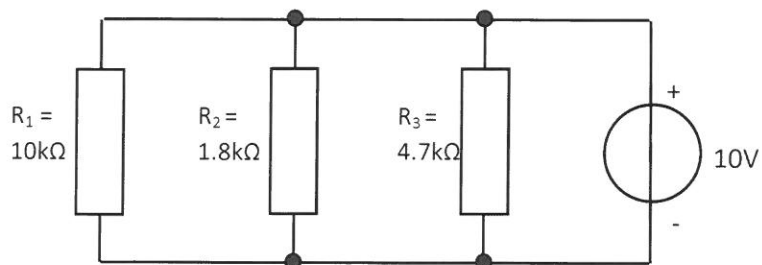
$$V_1 = I \times R_1 = 8.54 \times 220 \times 10^{-3} = 1.8788 = 1.88V$$

$$V_2 = I \times R_2 = 8.54 \times 390 \times 10^{-3} = 3.3306 = 3.33V$$

$$V_3 = I \times R_3 = 8.54 \times 560 \times 10^{-3} = 4.7824 = 4.78V$$

good work.

Figure 1b resistors in parallel



The circuit was constructed on a circuit board with the resistors values as shown in figure 1b before connecting the ten volt power supply a multimeter was used to measure the total resistance of the circuit. After the power source was connected a multimeter was again used to measure the supply current and the current across each resistor.

The table below shows my measured values.

	Measured Values
Total resistance	1.12kΩ
Supply current	8.70mA
Current across each resistor	$R_1 = 1mA$ $R_2 = 5.53mA$ $R_3 = 2.14mA$

Calculations for resistors in parallel

Total Resistance

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_t} = \frac{1}{10000} + \frac{1}{1800} + \frac{1}{4700} = \frac{1}{8.68321513 \times 10^{-4}} = 1151.65\Omega = 1.15k\Omega$$

Supply Current

$$I = \frac{V}{R_t}$$

$$I = \frac{10}{1151.65} = 8.68mA$$

Current through each resistor

$$I_1 = \frac{V}{R_1} = \frac{10}{10000} = 1 \times 10^{-3} = 1mA$$

$$I_2 = \frac{V}{R_2} = \frac{10}{1800} = 5.555555556 \times 10^{-3} = 5.56mA$$

$$I_3 = \frac{V}{R_3} = \frac{10}{4700} = 2.127659574 \times 10^{-3} = 2.13mA$$

Well done.

Overall comment on results

The two tables below show the measurements from the circuits the calculated values and then the differences between the two values.

Resistors in series

	Measured Values	Calculated values	Differences
Total resistance	1154Ω	1170Ω	16Ω
Supply current	8.54 mA	8.54mA	0mA
p.d across resistors	R ₁ = 1.84V, R ₂ = 3.35V, R ₃ = 4.80V	R ₁ = 1.88V, R ₂ = 3.32V, R ₃ = 4.77V	R ₁ = 0.04V R ₂ = 0.03V R ₃ = 0.03V

Resistors in parallel

	Measured Values	Calculated values	Differences
Total resistance	1.12kΩ	1.15kΩ	0.03kΩ
Supply current	8.70mA	8.68mA	0.02mA
Current across resistors	R ₁ = 1mA, R ₂ = 5.53mA, R ₃ = 2.14mA	R ₁ = 1mA R ₂ = 5.56mA R ₃ = 2.13mA	R ₁ = 0mA R ₂ = 0.03mA R ₃ = 0.01mA

Overall comment on results

Each individual resistor can affect the measured value due to them having their own tolerance of +/- 10%, an example of this is when using a resistor that is 560Ω the potential resistance it could have is between 504Ω - 616Ω and this tolerance is in all of the resistors. This could affect the results all though there were very small differences between the measured and calculated results.

The multimeter could have affected the measurements due to calibration problems as well as the leads having a high resistance within them. Both the leads and the multimeter could have been damaged by other students.

All though there were very little differences between the measured values and the calculated values the reasons above more than likely caused them as well as rounding up and down when doing the calculations.

As said in Bird's electrical and electronic principles Kirchoffs current law states "At any junction in an electrical circuit the total current flowing towards that junction is equal to the total current flowing away from the junction" (2007, p194) this is relevant to the resistors in series as the current stays the same throughout the complete circuit.

Kirchoffs voltage law states "In any closed loop in a network, the algebraic sum of the voltage drops taken around the loop is equal to the resultant e.m.f. acting in that loop" (2007, p.194) This is relevant as the voltage drop across each resistor totals the whole voltage within the system.

Task 2 – Capacitors

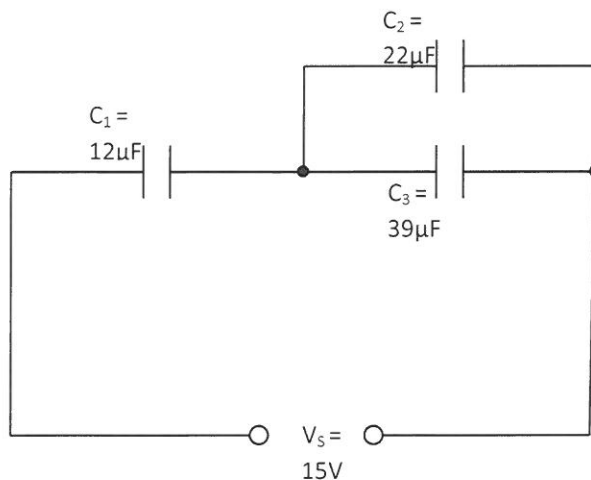
Capacitors are usually used in circuits in which an electrical charge needs to be stored. Capacitors are formally known as condensers and the simplest way to describe a way capacitors are made is a dielectric insulating material in-between two plates.

The formula underneath is the formula used to calculate the capacitance of an electrical component.

$$C = \frac{Q}{V}$$

When using this formula C is equal to the capacitance, Q is equal to the charge and V is equal to the voltage.

Figure 2 capacitor in combinational circuit



Explaining the construction and function of a capacitors

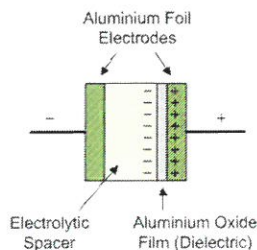
A capacitor is made up of two plates and a dielectric material acting as an insulator between them which also has the ability to store electrical charge in it. The type of capacitor chosen to be used in a specific circuit is chosen based on the dielectric strength of the insulating material that is between the two plates which are usually foil. A capacitors rating is usually given in 'farads' which is named after British scientist Michael Faraday. Hughes states "Early experiments found that conductors would hold much greater electric charges provided that they were held in close proximity to one another yet kept apart" (2008, p.93). Hughes also states that the simplest type of capacitor "can be made from two strips of metal foil sandwiched with two thin layers of insulation. Waxed paper is a suitable insulator" (2008, p. 93) The most common use of capacitors according to John Bird "are used to smooth rectified a.c. outputs, they are used in telecommunication equipment such as radio receivers." (2007, p.55)

Different types of capacitors

Electrolytic capacitor

As the figure 2a below shows this type of capacitor is constructed with an aluminium foil between the positive and negative legs of the capacitor. It is very similar to a paper capacitor and Bird states that the insulating material that splits the two legs is "impregnated with electrolyte" (2007, p.68). The application of the electrolytic capacitor depends on the formation of the thin aluminium oxide on the positive plate. The normal working voltages of these type of capacitors are "6V – 600V". (2007, p.68) The accuracy of these capacitor is "generally not very high." But Bird says "These capacitors possess a much larger capacitance than other types of capacitors of similar dimensions due to the oxide film." (2007, p.69) These oxides films are only couple of microns in thickness which contributes to the overall capacitance being higher than the capacitors with similar dimensions the effectiveness of these capacitors is limited as they can only be used in DC circuits.

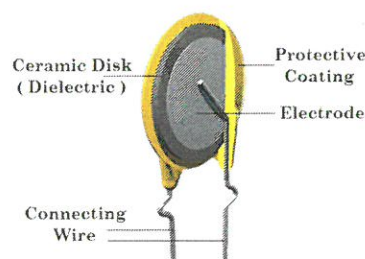
Figure 2a – Electrolytic capacitor



Ceramic capacitor

The ceramic material used in the construction of the ceramic capacitor has an effect on the value of the capacitor, as figure 2b shows below the two connecting wires are connected either side of the ceramic disk. Ceramics are a good insulating material to use when looking for a capacitor that has a high capacitance value but are actually small in the physical size. Bird writes that "ceramic materials have a very high permittivity and this enables capacitors of high capacitance to be made which are of a small physical size". These capacitors can be used at higher voltages and the ratings range from "1pF to 0.1μF and may be used in high frequency electronic circuits to a wide range of temperatures." (2007, p.68)

Figure 2b – Ceramic capacitor



Capacitor calculations

a) Total capacitance

$$C_{23} = C_2 + C_3 = 22 + 39 = 61\mu F$$

$$C_T = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{12 \times 61}{12 + 61} = 10.02\mu F$$

b) Total charge

$$Q_T = C_T \times V = 10.02 \times 15 = 150.3\mu F$$

Wrong unit "μC"

c) Charge in each capacitor

Charge for $C_1 = Q_T$ as it is connected in series so, $Q_1 = Q_T = 150.3\mu F$

$$\text{So, } V_1 = \frac{Q_1}{C_1} = \frac{150.3}{12} = 12.53V$$

$$\text{And, } V_2 = V - V_1 = 15 - 12.53 = 2.47V$$

$$\text{This means, } Q_2 = C_2 \times V_2 = 22 \times 2.47 = 54.34\mu F$$

$$Q_3 = C_3 \times V_2 = 39 \times 2.47 = 96.33\mu F$$

d) Individual energy

$$W_1 = \frac{1}{2} C_1 \times V_1^2 = \frac{1}{2} \times 12 \times 12.53^2 = 9422\mu J = 942.2\mu J$$

$$W_2 = \frac{1}{2} C_2 \times V_2^2 = \frac{1}{2} \times 22 \times 2.47^2 = 67.11\mu J$$

$$W_3 = \frac{1}{2} C_3 \times V_2^2 = \frac{1}{2} \times 39 \times 2.47^2 = 118.97\mu J$$

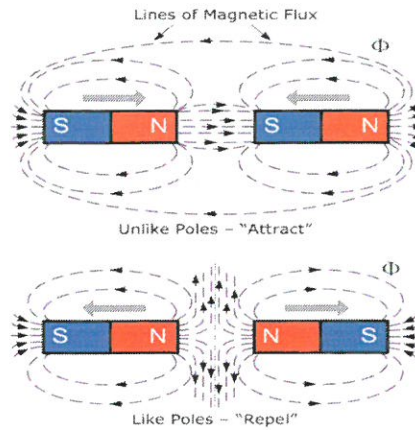
e) Total Energy

$$W_T = \frac{1}{2} C_T \times V^2 = \frac{1}{2} \times 10.02 \times 15^2 = 1127.25\mu J$$

Task 3

Principles of permanent magnets

Figure 3 – Magnetic fields



The area directly around a magnetic is known as the magnetic field. Figure 3 above shows the two different poles of permanent magnets, as can be seen at the top of the image the dislike poles attract to each other and the bottom of the image shows that like poles repel against each other. Permanent magnets are constructed of a ferromagnetic material an example of this type of material are nickel and cobalt. The only materials that permanent magnets can attract are other ferromagnetic materials

The main characteristics of magnetic fields are as follows the first two are the magnetic fields "complete closed loops or paths" and "they never intersect and always have a definite direction." This definite direction is "from the north pole to the south pole on the outside of the magnet". The last characteristic was stated earlier and it is that like poles attract and there is repulsion between dislike poles. (Bird, 2007, p.73)

Solving problems 2a and 2b

A.

$$B = \frac{\phi}{a}$$

$$a = 250 \times 120 = 30000 \text{ mm}^2 = 3 \times 10^{-6} \text{ m}^2 \quad \times$$

$= 0.003 \text{ m}^2$

$$B = \frac{120 \times 10^{-6}}{3 \times 10^{-6}} = 40 \text{ T} \quad \times$$

B.

$$B = \frac{\emptyset}{a}$$

$$a = \frac{\emptyset}{T} = \frac{340 \times 10^{-3}}{1.5} = 0.22667 \text{ m}^2$$

$$\pi r^2 = 0.22667 \text{ m}^2$$

$$r^2 = \frac{0.22667}{\pi}$$

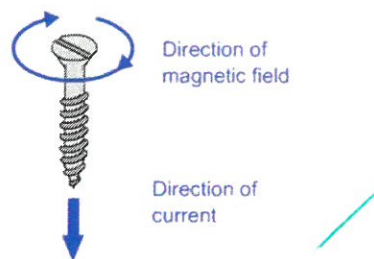
$$r = \sqrt{\frac{0.22667}{\pi}} = 0.2686 \text{ m} = 268.6 \text{ mm}$$

Operation and construction of electromagnet

An electromagnet is soft metal that turns into a magnet when an electrical current is passed through it. Magnetic fields can be produced by an electric current as well as permanent magnets. The direction that the current is flowing in determines whether the magnetic field rotates clockwise or anticlockwise.

The screw rule is one of the best ways of representing the direction of the electric fields as the figure 3a below shows.

Figure 3a



The screw rule can only be used for a standard right hand thread screw and it states when the screw is screwed in the direction of the current it moves in the direction of the magnetic field inside the solenoid. The direction of the magnetic field inside the solenoid is from south to north." (2007, p.86)

Two other ways of evaluating the electromagnetic fields are by using Fleming's left hand and right hand rules. These rules are shown in figure 3b and figure 3c below.

Figure 3b

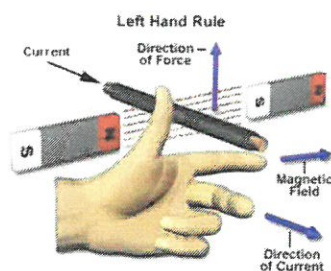
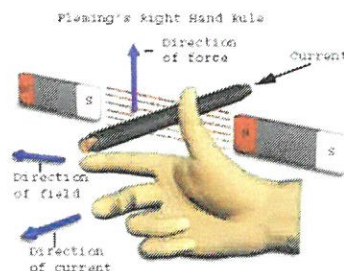


Figure 3c



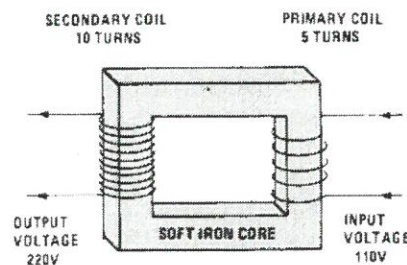
Fleming discovered you could use your fingers to determine the state of the magnetic field when the current is flowing. In the left hand rule as can be seen in the first figure the thumb is the direction of the force, the second finger is the direction of the magnetic field and the middle finger is the direction of the current. In the right hand rule the thumb is the direction of the force, the second finger is the direction of the field and the middle finger is the direction of the current.

Applications of electromagnets

Transformer

A transformer is a big electric device that used electromagnets in order to work. Transformers are devices that either step up or step down a voltage or current. In basic term a transformer consists of two coils of wires one side is known as the primary in which the ac input is connected to and the other is the secondary coil which the ac output leaves the device. These two coils are not electrically connected they use the principle of electromagnetism to work. As the primary coil is wound around an iron core they are easily magnetised and can carry the magnetic fields form the primary coil to the secondary coil. The figure below shows a 220V – 110 Volt transformer.

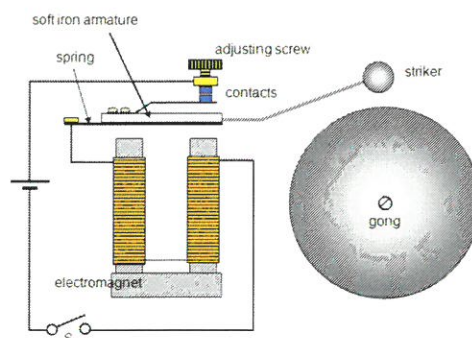
Figure 3d – simple transformer construction



Electric Bell

A smaller use of an electromagnet within a circuit is an electric bell as the figure 3e below shows.

Figure 3e



This circuit is a single stroke bell, once the button is pushed in the current passes through the circuit and the coil. The armature also has a striker which hits the gong to make the sound when the current passes through. Bird implies that this circuit works when "the iron-cored coil is energised the soft iron armature is attracted to the electromagnet." (Bird 2007, p.87) When the circuit is broken the current stops passing through so the electromagnet and the rest of the circuit is de-energised and is ready to be pressed by the next person where the operation starts again.

Solving problems 4a and 4b

A.

$$F = BIL$$

$$B = \frac{\phi}{a}$$

$$a = 0.06 \times \pi = 0.0113m^2$$

$$B = \frac{0.4 \times 10^{-3}}{0.0113} = 0.035T$$

$$0.035 \times 8 \times 0.32 = 0.0896N$$

B.

$$F = BIL$$

$$B = \frac{F}{I \times L} = \frac{80}{25 \times 0.4} = 8T$$

$$B = \frac{\phi}{a} = a = \frac{\phi}{B} = \frac{1.27 \times 10^{-3}}{8} = 158.75m^2$$

$$a = \pi r^2 = r = \sqrt{\frac{a}{\pi}} = \sqrt{\frac{158.75 \times 10^{-6}}{\pi}} = 7.11 \times 10^{-3}m$$

$$d = 7.11 \times 10^{-3} \times 2 = 0.01422 = 14.22mm$$

Task 4

AC Circuits

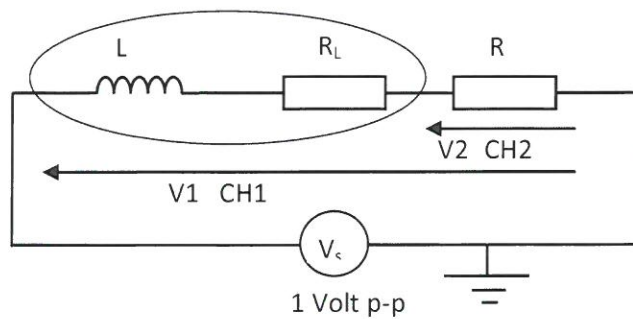
Peak voltage - $0.5 \times 7 = 3.5V$ ✓

Frequency - $\frac{1}{20} = 0.05Hz$ ✓

Average voltage - $0.637 \times 3.5V = 2.23V$ ✓

Root mean square (rms) voltage - $\frac{3.5}{\sqrt{2}} = 2.47V$ ✓

Figure 4 – AC circuit constructed



$L = 1mH, R = 10\Omega, R_L = ?\Omega$

The measurements I recorded from the circuit are;

$L = 1mH$

$R = 9.97\Omega$

$R_L = 2.55\Omega$ ✓

Table of measurements

Frequency (f)	CH1 (V)	CH2 (V)	Time	Calculated values		
(kHz)	<i>pk to pk</i> Voltage	<i>pk to pk</i> Voltage	Difference (<i>between peaks</i>)			
			(T2-T1)	Time for 1 cycle (T)	Fraction of cycle	Phase
	mV	mV	Seconds	1/f	(T2-T1)/T	Angle (°)
						(fraction x 360)
1	221.76	152.46	88	0.001	0.088	31.68
2	277.2	148.5	60	0.0005	0.12	43.2
3	336.6	144.54	46	0.000333	0.138	49.68
4	403.92	142.56	44	0.00025	0.176	63.36
5	467.28	134.64	38	0.0002	0.19	68.4
6	514.8	130	32	0.000167	0.192	69.12
7	570.24	124.74	28	0.000143	0.196	70.56
8	609.84	118.8	26.4	0.000125	0.2112	76.032
9	657.36	112.86	23.2	0.000111	0.2088	75.168

Table of calculations

Frequency (f - kHz)	$X_L (\Omega)$ ($2\pi fL$)	R_T ($R + R_L$)	$Z (\Omega)$	Current (A)	Phase Angle (°)	Check with b) above
1	6.28	12.52	14.01	0.071	26.65	
2	12.57	12.52	17.74	0.056	45.11	
3	18.85	12.52	22.63	0.044	56.41	
4	25.13	12.52	28.08	0.036	63.52	
5	31.42	12.52	33.82	0.030	68.27	
6	37.70	12.52	39.72	0.025	71.63	
7	43.98	12.52	45.73	0.022	74.11	
8	50.27	12.52	51.80	0.019	76.01	
9	56.55	12.52	57.92	0.017	77.52	

Calculations

Need to state the frequency and formulas

$$X_L = 2\pi \times 5 \times 10^3 \times 0.001 = 31.42\Omega$$

$$R_T = 2.55 \times 9.97 = 12.52\Omega$$

$$Z (\Omega) = \sqrt{12.52^2} + \sqrt{31.42^2} = 33.82\Omega$$

$$\text{Current (A)} = \frac{0.001}{33.82} \times 10^{-3} = 0.030 \text{ A}$$

$$\text{Phase angle } ^\circ = \frac{31.42}{12.52} \times \frac{180}{\pi} = 68.27^\circ$$

? No.

$$= \tan^{-1} \left(\frac{X_L}{R} \right)$$

Overall comment on results

The main reason that there is a slight difference between the calculations and the practical results is due to parallax error. This error is most likely to occur when reading the values off the oscilloscope. It was very difficult to read the values as the wave was continually moving and you had to be at the correct angle to get the correct reading. Another cause of variations between the results could be the condition of the equipment as lots of different students use them they could easily get damaged and then put back into storage until the next student used it. The components used within the system can be another cause of variations due to internal resistances and values of each individual component. The main variations between the results were the phase angle this was due to reading the values off the oscilloscope and rounding up and down with the calculations.

References for figures

Task 1 – DC circuits

DC waveform

<https://voltsnbolts.wordpress.com/2014/09/23/waveforms-explained/> ✓

Task 2 – Capacitors

2a - https://www.electronics-tutorials.ws/capacitor/cap_2.html

2b - <https://electricalfundablog.com/ceramic-capacitor-composition-types-properties-applications/> ✓

Task 3 – Magnetism

3a - <http://www.simplyinfo.net/article.php?title=amperes-swimming-rule-and-maxwells-cork-screw-rule>

3b - <https://www.quora.com/What-is-the-State-Flemings-left-hand-rule>

3c - <https://www.electrical4u.com/fleming-left-hand-rule-and-fleming-right-hand-rule/>

3d - <https://physics.stackexchange.com/questions/51936/how-do-transformers-work>

3e - http://www.schoolphysics.co.uk/age11-14/Electricity%20and%20magnetism/Electromagnetism/text/Electric_bell/index.html ✓

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