

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:	Lance Rutherford
Assignment Title:	Electrical Principles	Word count (or equivalent):	2000
Submission deadline:	15/01/20	Return date of provisional marks & written feedback:	29/01/21
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
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	25	15.8
Task 1 achieved 65%. Task 2 achieved 70%. Task 3 achieved 50%. Task 4 achieved 68%. Knowledge of the basic underlying concepts and principles is accurate with a good understanding in most areas. You have shown a full understanding of the requirements for the calculation work in each task but in some of the tasks you lack detail in the discussions of some of the concepts.		
3. Cognitive and Intellectual Skills	15	8
Task 1 achieved 55%. 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	27.3
Task 1 achieved 75%. Task 4 achieved 81%. 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	6.3
Mostly coherent, organised and accurate work, in a suitable structure and is for the most part clearly expressed.		

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)		66%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		



ELECTRICAL PRINCIPLES

HNC Electrical/ Electronic Engineering, Power
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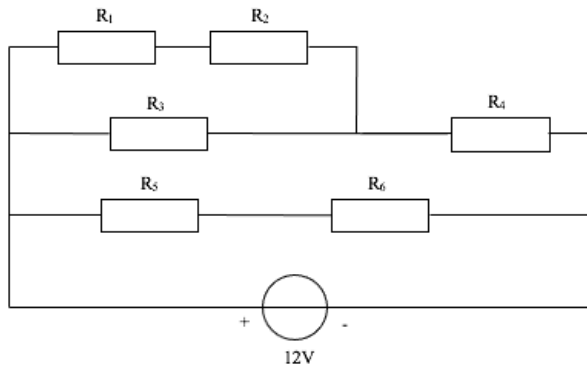
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Task 1 – DC Circuits

The figure below shows results collected following the construction of a combination circuit made of a collection of resistors in series and parallel. The circuit was built on a breadboard, connected to a 12V power supply.

1. Circuit total resistance before connecting power supply $R_t = 311 \Omega$



$R_1 = 180 \Omega$
 $R_2 = 680 \Omega$
 $R_3 = 220 \Omega$
 $R_4 = 330 \Omega$
 $R_5 = 270 \Omega$
 $R_6 = 560 \Omega$

2. Figure 1 of results has been constructed, based off the combination circuit of resistor in part 1. The results were gathered using a multimeter.

	Measured	
R_t	311Ω	✓
V1	0.867 V	✓
V2	3.28 V	✓
V3	4.15 V	✓
V4	7.75 V	✓
V5	3.8 V	✓
V6	7.98 V	✓
I	38.2 mA	✓
I1	4.84mA	✓
I2	4.84mA	✓
I3	18.61mA	✓
I4	24.1mA	✓
I5	14.25mA	✓
I6	14.25mA	✓

Figure 1

3. The calculations are the theoretical values of the combination circuit in this task.

a) Total Resistance

$$R_{1,2} = R_1 + R_2$$

$$R_{1,2} = 180 + 680 = 860 \text{ Ohms}$$

$$R_{1,2,3} = \frac{R_{1,2} \times R_3}{R_{1,2} + R_3} = \frac{860 \times 220}{860 + 220} = 175.185 \text{ Ohms}$$

$$R_{1,2,3,4} = R_{1,2,3} + R_4$$

$$R_{1,2,3,4} = 175.185 + 330 = 505.185$$

$$R_{5,6} = R_5 + R_6$$

$$R_{5,6} = 270 + 560 = 830$$

$$R_t = \frac{R_{1,2,3,4} \times R_{5,6}}{R_{1,2,3,4} + R_{5,6}} = \frac{505.185 \times 830}{505.185 + 830} = 314.041 \text{ Ohms}$$

b) Supply Current

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

$$I = \frac{12}{314.041} = 38.21 \text{ mA}$$

c)d) Current and Potential Difference in each resistor

$$I_5 = I_6 = \frac{V}{R_{5,6}} = \frac{12}{830} = 14.458 \text{ mA}$$

$$V_5 = I_5 \times R_5 = 14.458 \times 10^{-3} \times 270 = 3.903 \text{ V}$$

$$V_6 = I_6 \times R_6 = 14.458 \times 10^{-3} \times 560 = 8.097 \text{ V}$$

$$I_4 = \frac{V}{R_{1,2,3,4}} = \frac{12}{505.185} = 23.754 \text{ mA}$$

$$V_4 = I_4 \times R_4 = 23.754 \times 10^{-3} \times 330 = 7.837 \text{ V}$$

$$V_3 = V - V_4 = 12 - 7.837 = 4.163 \text{ V}$$

$$I_3 = \frac{V_3}{R_3} = \frac{4.163}{220} = 18.923 \text{ mA}$$

$$I_1 = I_2 = \frac{V_3}{R_{1,2}} = \frac{4.163}{860} = 4.841 \text{ mA}$$

$$V1 = I1 \times R1 = 4.841 \times 10^{-3} \times 180 = 0.871V \quad \checkmark$$

$$V2 = I2 \times R2 = 4.841 \times 10^{-3} \times 680 = 3.291V \quad \checkmark$$

Excellent work.

c)

$$I1 = 4.841 \text{ mA}$$

$$I2 = 4.841 \text{ mA}$$

$$I3 = 18.923 \text{ mA}$$

$$I4 = 23.754 \text{ mA}$$

$$I5 = 14.458 \text{ mA}$$

$$I6 = 14.458 \text{ mA}$$

d)

$$V1 = 0.871 \text{ V}$$

$$V2 = 3.391 \text{ V}$$

$$V3 = 4.163 \text{ V}$$

$$V4 = 7.837 \text{ V}$$

$$V5 = 3.903 \text{ V}$$

$$V6 = 8.097 \text{ V}$$

4)

Using Multisim, a set of results were gathered from the combination circuit built in the program. Figure 2 shows the results from Multisim, calculations and measured values from the physical circuit.

	Measured	MultiSim	Calculations
Rt	311 Ω	311 Ω	314.04 Ω
V1	0.867 V	0.870 V	0.871 V
V2	3.28 V	3.29 V	3.391 V
V3	4.15 V	4.161 V	4.163 V
V4	7.75 V	7.839 V	7.837 V
V5	3.8 V	3.904 V	3.903 V
V6	7.98 V	8.096 V	8.097 V
I	38.2 mA	38.21 mA	38.21 mA
I1	4.84mA	4.839 mA	4.841 mA
I2	4.84mA	4.839 mA	4.841 mA
I3	18.61mA	18.916 mA	18.923 mA
I4	24.1mA	23.754 mA	23.754 mA
I5	14.25mA	14.458mA	14.458 mA
I6	14.25mA	14.458mA	14.458 mA

Figure 2

5)

Results gathered for the circuit are different. As seen from the table of results V1 for example, the measured result from the constructed circuit is 0.867V, the MultiSim value is 0.870V and the calculated, theoretical value is 0.871V. Although the difference is very small, it can be explained. Multisim is more accurate as it is a computer designed circuit which works with exact resistor and supply values. When working with exact figures, the values are likely to be correct. The measured results taken from the constructed circuit results were slightly lower than the MultiSim values. The measured results can be affected by external factors such as room temperature. Measured with a multimeter which has a tolerance can affect the measured results. The components used in the circuits construction also have tolerances and have been used before so the internal parts of these may be damaged or the actual value is closer to the higher or lower ends of the tolerances. The calculations gathered are slightly higher than the MultiSim value at 0.871V compared to 0.870V as it is a small difference this can be explained. When calculating the final figures, rounding up can bring the final numbers up as seen in the table above, the majority of calculated results are higher. In these calculations Kirchoffs can be used. The independent currents and voltages can be calculated using loop analysis to separate them and reduce the amount of mathematics needed to perform certain calculations.

Kirchoffs first, current law states that *"total current or charge entering a junction or node is exactly equal to the charge leaving the node as it has no other place to go except to leave, as no charge is lost within the node"*ⁱ. This means that the sum of all current entering a node is equal to all current exiting the node, suggesting that current cannot accumulate or be produced at a node. Kirchoffs second Law or the voltage law states that *"in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop"*ⁱⁱ. This means that travelling across a loop, the voltages across each of the elements in the circuit will add to zero.

How did this apply to your circuit?

Task 2 – Capacitors

1) A capacitor is an electronic component which is used to store energy within a circuit. A capacitor consists of two or more parallel plates. The plates are separated by an insulator which can be one of a variety of materials. The separating material is known as the dielectric. One example is a paper capacitor. This type of capacitor's dielectric is paper which is between two foil sheets. This structure is then rolled up and put into a plastic cylinder. *"The typical values of this type of capacitor are from 0.001 to $2\mu\text{F}$ and voltages of up to 2000V".*ⁱⁱⁱ Another example is a ceramic capacitor, in this example, the dielectric is a disk made of a ceramic material. Typical values of a ceramic capacitor are between 1nF and 1 μF , although values of up to 100 μF are possible. Values of capacitors can be changed by using a different type of capacitor called a Variable air capacitor. These consist of two metal plates, one is fixed and the other can move, which is the variable. The two plates rotate on a spindle. As the variable moving plate is rotated, the meshing between the two plates varies with the capacitance, moving from a lower to higher or the opposite. This type of capacitor is used in radios and electronics circuits in areas where a variable capacitance is required. The typical minimum values of a Variable air capacitor range from 500pF to 1000pF. ✓

There are other methods that can be used to change the capacitance values.



Paper Capacitor

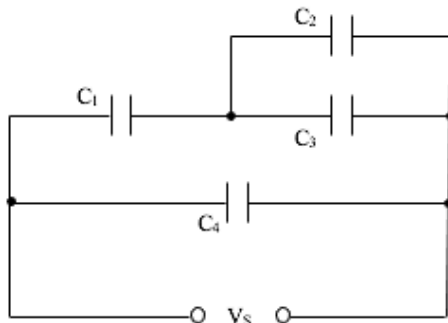


Ceramic Capacitor



Variable Capacitor

2) Below are the calculations performed in order to find charge, capacitance and energy in a capacitor circuit.



$C_1 = 10\ \mu\text{F}$
 $C_2 = 22\ \mu\text{F}$
 $C_3 = 39\ \mu\text{F}$
 $C_4 = 3.3\ \mu\text{F}$
 $V_s = 25\ \text{V}$

a) Equivalent Circuit Capacitance

$$C_{2,3} = C_2 + C_3 = 22\mu F + 39\mu F = 61\mu F$$

$$C_{1,2,3} = \frac{C_1 \times C_{2,3}}{C_1 + C_{2,3}} = \frac{10 \times 61}{10 + 61} = 8.592\mu F$$

$$C_T = C_4 + C_{1,2,3} = 3.3 + 8.592 = 11.892\mu F$$

b) Total Charge

$$Q_T = C_T \times V = 11.892 \times 10^{-6} \times 25 = 297.3\mu C$$

c) Charge in each capacitor

$$Q_4 = C_4 \times V = 3.3 \times 10^{-6} \times 25 = 82.5\mu C$$

$$Q_{1,2,3} = C_{1,2,3} \times V = 8.596 \times 10^{-6} \times 25 = 214.8\mu C$$

$$Q_1 = Q_{1,2,3}$$

$$V_1 = \frac{Q_1}{C_1} = \frac{214.8}{10} = 21.48V$$

$$V_{2,3} = \frac{Q_1}{C_{2,3}} = \frac{214.8}{61} = 3.52V$$

$$Q_2 = C_2 \times V_{2,3} = 22 \times 10^{-6} \times 3.52 = 77.44\mu C$$

$$Q_3 = C_3 \times V_{2,3} = 39 \times 10^{-6} \times 3.52 = 137.28\mu C$$

$$Q_1 = 214.8\mu C$$

$$Q_2 = 77.44\mu C$$

$$Q_3 = 137.28\mu C$$

$$Q_4 = 82.5\mu C$$

d) Energy stored in each capacitor

$$W_1 = \frac{1}{2} C_1 \times V_1^2 = \frac{1}{2} 10 \times 10^{-6} \times 21.48^2 = 2.31mJ$$

$$W_2 = \frac{1}{2} C_2 \times V_{2,3}^2 = \frac{1}{2} 22 \times 10^{-6} \times 3.52^2 = 136.29\mu J$$

$$W3 = \frac{1}{2} C3 \times V2,3^2 = \frac{1}{2} 39 \times 10^{-6} \times 3.52^2 = 241.61 \mu J \checkmark$$

$$W4 = \frac{1}{2} C4 \times V4^2 = \frac{1}{2} 3.3 \times 10^{-6} \times 25^2 = 1.03 mJ \checkmark$$

e) Total energy stored in circuit

$$WT = \frac{1}{2} CT \times V^2 = \frac{1}{2} 11.892 \times 10^{-6} \times 25^2 = 3.716 mJ \checkmark$$

well done.

Task 3 – Magnetism

1a)

Permanent Magnets

The magnetic field surrounding a bar magnet, otherwise known as a permanent magnet, can be observed using a magnetograph. A magnetograph can be created by placing a piece of paper over a magnet and spreading iron filings over the sheet. The filings align themselves with the lines of magnetic force produced by the magnet or magnets. The lines of force or filings show where the magnetic field exits the material at one pole and enters the material at another pole along the length of the magnet. When using a magnetograph, only two dimensions can be observed although the magnetic lines of force are also in the third dimension.

2a)

$$A = L \times H = 0.22 \times 0.12 = 0.0264 m^2 \checkmark$$

$$B = \frac{\Phi}{A} = \frac{130 \times 10^{-6}}{0.0264} = 4.92 mT \checkmark$$

You have not explained magnetic fields.

b)

$$B = \frac{\Phi}{A} \quad A = \frac{\Phi}{B} \quad A = \pi r^2$$

$$A = \frac{611 \times 10^{-3}}{1.9} = 0.322 m^2 \checkmark \quad \pi r^2 = 0.322 m^2 \checkmark$$

$$r^2 = \frac{0.322}{\pi} \checkmark \quad r = \sqrt{\frac{0.322}{\pi}} = 0.320 m^2 \checkmark$$

Electromagnets

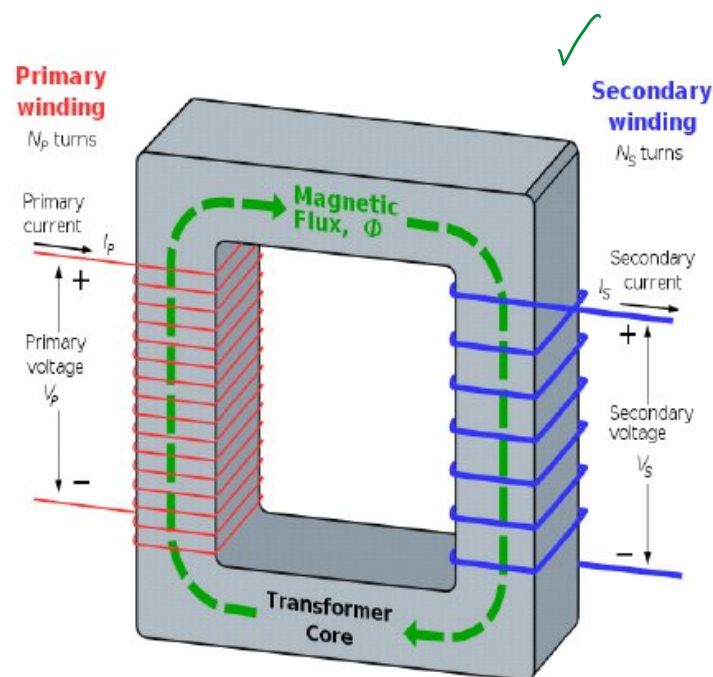
An electromagnetic field, sometimes referred to as an EM field, is generated when charged particles, such as electrons are accelerated. All electrically charged particles are surrounded by

electric fields. Charged particles in motion produce magnetic fields. When the velocity of a charged particle changes, an electromagnetic field is produced. The poles of an electromagnet can even be reversed by reversing the flow of electricity. An electromagnet works because an electric current produces a magnetic field. Electromagnetic fields are typically generated by alternating current in electrical conductors. The frequency of the AC can range from one cycle in thousands of years to trillions or quadrillions of cycles per second in extreme cases.

You have not really explained the operation of electromagnetics. What?

Transformer construction, methods to reduce power loss

A transformer consists of two inductive windings, the primary coil and the secondary coil. The core of the transformer is usually laminated steel/iron to avoid energy losses through eddy current. The coils are insulated from each other to avoid shorting. Transformers may also consist of a container like tank to provide oil for cooling purposes for the coils. This reduces energy loss through heating and decreases chance of failure. A potential difference gives an alternating current through the primary coil, the iron laminated core increases the strength of the magnetic field. The change in this field, induces a potential difference in the secondary coil. This potential difference produces an alternating current in the external circuit. ✓



Shown is a basic image of a typical transformer. The image shows, the typically cast-iron core, with the primary and secondary windings. The diagram depicts the direction of the magnetic.^{vii}

After stepping down voltage, the power will be transmitted via pylons multiple times before it meets the consumer. The typical AC power supply system produces 230V which will have been

stepped up to around 220kV, then stepped back down again to a suitable value for households and other consumers. ✓

Eddy Current Loss

Eddy current loss is a type of power loss in a transformer where leakage flux produces its own eddy current. These eddy currents produce their own magnetic field which interacts with the primary coil of the transformer. These eddy currents can produce heat, affecting the transformers performance and creating potential for failure. One way of reducing eddy current loss in a transformer is by constructing the core with layers of laminated material rather than one solid core material. By introducing the laminated layers, small gaps between the plates are created. This reduces eddy current losses because it is easier for flux to flow through iron or other core materials than air or transformer oil which will fill the gaps. ✓

Hysteresis Loss

Hysteresis loss is caused by the magnetisation and de-magnetisation of the core as current flows forward and in reverse. The current increases, the magnetic flux also increases but when the current is decreased, the flux does not decrease at the same rate, it decreases more gradually. In order for the flux to reach zero, the magnetising force must be applied in the opposite direction. In order to achieve the full magnetisation and demagnetisation, extra work is being done to make the field inside. This extra work done is known as hysteresis loss. This loss can be reduced by using core materials which have the smallest hysteresis loop area. Materials such as silicon steel have a small hysteresis loop area so is commonly used as a core material. ✓

3a) The results below are of induced e.m.f, maximum e.m.f and coil rotation speeds.

$$\phi = \frac{L \times I}{N} \quad \phi = \frac{2.5 \times 1.6}{700} = 5.71 \times 10^{-3} = 5.71 \text{mWb} \quad \checkmark$$

$$E = \frac{-Nd\phi}{dt} = \frac{-700 \times 5.71 \times 10^{-3}}{20 \times 10^{-3}} = -199.85 \text{V} \quad \checkmark$$

b)i)

$$E = 2 \times NBlv \sin \theta$$

$$\omega t = \left(\frac{1200 \times 2\pi}{60} \right) \times \left(\frac{0.06}{2} \right) = 7.770 \text{m/s} = V \quad \checkmark$$

$$E = 2 \times 70 \times 1.2 \times 0.1 \times 7.770 \times \sin 90 = 130.536 \text{V} \quad \times$$

ii)

$$V = \frac{E}{2NBl} = \frac{80}{2 \times 70 \times 1.2 \times 0.1} = 4.672 \text{m/s} \quad \checkmark$$

$$V_{rpm} = \frac{v \times 60}{2\pi} \times \frac{2}{l} \quad V_{rpm} = \frac{4.672 \times 60}{2\pi} \times \frac{2}{0.06} = 1487.14 \text{ rev/min}$$

Task 4 - AC Circuits

1) Using an oscilloscope, the following results have been calculated from a sine wave.

a) Peak Voltage

$$V_p = \frac{2 \times 6.6}{2} = \frac{13.2}{2} = 6.6V$$

b) Frequency

$$F = \frac{1}{T} = \frac{1}{20 \times 10^{-3}} = 50Hz$$

c) Average Voltage

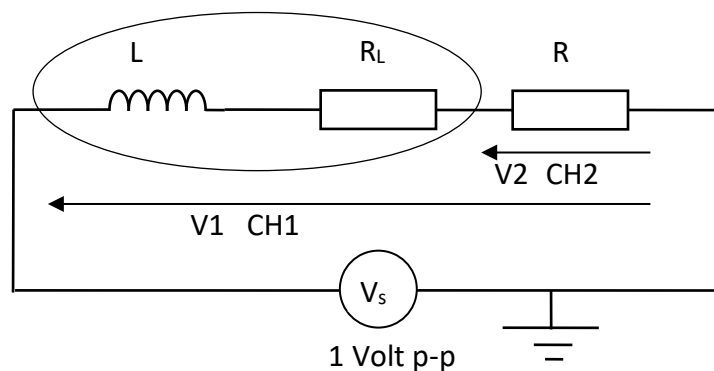
$$V_{av} = 0.637 \times V_p$$

$$V_{av} = 0.637 \times 6.6 = 4.204V$$

d) RMS voltage

$$V_{rms} = \frac{V_p}{\sqrt{2}} = \frac{6.6}{\sqrt{2}} = 4.667V$$

2)



3) After measuring values from the RL circuit above, the values gathered are as follows. These values will be used later in the Task.

$L = 1.004 \text{ mH}$

$R = 18.03 \Omega$

$R_L = 2.5 \Omega$

4) Figure 3 presents the results gathered from using an oscilloscope at different frequencies.

Frequency (f) KHz	CH1 (V) <i>pk to pk Voltage</i>	CH2 (V) <i>pk to pk Voltage</i>	Time Difference (Between Peaks) (T2-T1) (μ S)	<i>Calculated values</i>		
				Time for 1 cycle (T) (mS)	Fraction of cycle (T2-T1)/T	Phase Angle ($^{\circ}$) (fraction*360)
1	1	0.67	38.6	1.000	0.0386	13.896
2	1	0.78	37.8	0.500	0.0756	27.216
3	1	0.83	34.3	0.333	0.1029	37.044
4	1	0.88	31.4	0.250	0.1256	45.216
5	1	0.91	28.6	0.200	0.143	51.48
6	1	0.95	27	0.167	0.162	58.32
7	1	0.96	24.6	0.143	0.1722	61.992
8	1	0.97	23	0.125	0.184	66.24
9	1	0.97	20.6	0.111	0.1854	66.744

Figure 3

These values were gathered during a practical task using a power supply, oscilloscope and the RL circuit shown previously in the task. An RL circuit consists of an inductor, shown as L in (2), which is connected in series to a resistor RL, connected to another resistor in series R.

5) Values have been taken and used to calculate the following information at different frequencies.

$$L = 1.004 \text{ mH} \quad R = 18.03 \, \Omega \quad RL = 2.5 \, \Omega$$

Frequency (f - kHz)	Reactance, $X_L (\Omega)$ ($2\pi fL$)	Total Resistance $R_T (R + RL)$	Impedance $Z (\Omega)$	Current (A)	Phase Angle ($^\circ$)
1	6.31	20.53	21.48	0.0466	17.08
2	12.62	20.53	24.10	0.0415	31.57
3	18.92	20.53	27.92	0.0358	42.67
4	25.23	20.53	32.53	0.0307	50.87
5	31.54	20.53	37.63	0.0266	56.94
6	37.85	20.53	43.06	0.0232	61.52
7	44.16	20.53	48.70	0.0205	65.07
8	50.47	20.53	54.48	0.0184	67.86
9	56.77 ✓	20.53 ✓	60.37 ✓	0.0166 ✓	70.12 ✓

Figure 4

The following results have been calculated using a value of 6kHz as an example of working for the tables above in part 5.

$$L = 1.004 \text{ mH} \quad R = 18.03 \, \Omega \quad RL = 2.5 \, \Omega$$

$$\text{Reactance, } XL = 2\pi fL = 2 \times 6 \times 10^3 \times 1.004 \times 10^{-3} = 37.85 \, \Omega$$

$$\text{Total Resistance, } RT = RL + R = 2.5 + 18.03 = 20.53 \, \Omega$$

$$\text{Impedance, } Z = \sqrt{RT^2 + XL^2} = \sqrt{20.53^2 + 37.85^2} = 43.06 \, \Omega$$

$$\text{Current, } I = \frac{V}{Z} = \frac{1}{43.06} = 0.0232 \text{ A}$$

$$\text{Phase Angle, } \theta = \tan^{-1} \frac{XL}{RT} = \tan^{-1} \frac{37.85}{20.53} = 61.52^\circ$$

6)

When an oscilloscope is used, the results and readings based on human accuracy and the ability to measure and choose where to take readings from. An example of this is deciding where zero is. The screens on the oscilloscopes used only had a certain degree of accuracy which was

affected by the resolution of these screens. More up to date oscilloscopes will have a greater resolution. Parallax error is another example of human error. Parallax error is the measurement made by viewing the subject. If the market is a significant distance from the subject, the parallax error will be larger. The measured object, therefore, would not be viewed from the correct place. Equipment loading is another factor which can affect results. Equipment loading is when the circuit begins to consume power and the energy can be converted to heat which can affect the results and the degree of accuracy achieved. ✓

The results in figure 4 and calculations, taking the values at 6kHz in part 5, the reactance was 37.85Ω which meets the calculations also at 37.85Ω , this is as a result of rounding. When decimal places are rounded, the final result will not be as accurate as using multiple decimal places as opposed to two. Each of the values in figure 4 are the same as the calculations made. This is because as stated, the results were correctly rounded. The true results measured from the multimeter were entered into the calculations to achieve this. ✓

You could have compared phase angles.

Throughout the assignment your calculation work has been very good.

In some of your explanations you really need more detail.

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