

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Thomas James	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:	15/01/25	Return date of provisional marks & written feedback:	29/01/25
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: Work which is submitted up to 1 week late will be capped at 40% for the first attempt and will be awarded a mark of 0% for re-assessment. Late submission penalties may be lifted only if there is an approved extenuating circumstances claim. Work submitted more than 1 week late will be considered as a non-submission and will not be marked. The work may be considered as a submission for reassessment if offered by an Examining Board or if there is an approved extenuating circumstances claim.		
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	10	4.2
Engagement with a limited range of mostly relevant and credible sources. Your references should be stated at the end of the assignment.		
2. Knowledge and Understanding Skills	40	23
Task 1 achieved 55%. Task 2 achieved 62%, Task 3 achieved 58%. Task 4 achieved 55%. Knowledge of the basic underlying concepts and principles is competent with a very good understanding in most areas.		
3. Cognitive and Intellectual Skills	10	3.8
Task 1 achieved 41%. Task 4 achieved 35%. Largely descriptive work, with superficial evaluation of the underlying concepts and principles for Task 1 and 4, tending towards description.		
4. Practical Application Skills	30	23.3
Task 1 achieved 82%. Task 4 achieved 73%. 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	4
Mostly ordered presentation and structure, and is for the most part clearly expressed. Next time you may want to use Equation Editor for the calculation work.		

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%)

58%

Task 1 – DC Circuits

Calculations

Task 1 Q3

Find R_t

$$R_T = (R_1 + R_2) // (R_3 + R_4) // (R_5 + R_6)$$

$$R_{12} = R_1 + R_2 = 560 + 270 = 750 \Omega$$

$$R_{123} = \frac{R_{12} \times R_3}{R_{12} + R_3} = \frac{750 \times 220}{750 + 220} = 170.1 \Omega$$

$$R_{1234} = R_{123} + R_4 = 170.1 + 680 = 850.1 \Omega$$

$$R_{56} = R_5 + R_6 = 1200 + 180 = 1380 \Omega$$

$$R_t = \frac{R_{1234} \times R_{56}}{R_{1234} + R_{56}} = \frac{850.1 \times 1380}{850.1 + 1380} = 526.1 \Omega$$

Supply current

$$I = \frac{V}{R_t} = \frac{12}{526.1} = 22.81 \times 10^{-3} = 22.81 \text{ mA}$$

Current and P.D. in each resistor

$$I_5 = I_6 = \frac{V}{R_{56}} = \frac{12}{1380} = 8.69 \text{ mA}$$

$$V_5 = I_5 \times R_5 = 8.69 \times 10^{-3} \times 1200 = 10.428 = 10.43 \text{ V}$$

$$V_6 = I_6 \times R_6 = 8.69 \times 10^{-3} \times 180 = 1.56 = 1.6 \text{ V}$$

$$I_4 = I - I_5 = 22.81 \times 10^{-3} - 8.69 \times 10^{-3} = 14.12 \text{ mA}$$

$$V_4 = I_4 \times R_4 = 14.12 \times 680 = 9.7 \text{ V}$$

$$V_3 = V - V_4 = 12 - 9.7 = 2.3 \text{ V}$$

$$I_3 = \frac{V_3}{R_3} = \frac{2.3}{220} = 10.45 \text{ mA}$$

$$I_3 = \frac{V_3}{R_3} = \frac{2.3}{220} = 10.45 \text{ mA}$$

$$I_1 = I_2 = I - (I_3 + I_5) = 3.67 \text{ mA}$$

$$V_1 = I_1 \times R_1 = (3.67 \times 10^{-3}) \times (560) = 2.05 \text{ V}$$

$$V_2 = I_2 \times R_2 = 3.67 \times 10^{-3} \times 270 = 0.99 \text{ V}$$

These values are a little bit off.

Power dissipation in each resistor

$$P = I \times V = I^2 R = \frac{V^2}{R}$$

$$P_1 = I_1 \times V_1 = 3.67 \times 10^{-3} \times 2.05 = 7.52 \text{ mW}$$

$$P_2 = I_2 \times V_2 = 3.67 \times 0.99 = 3.63 \text{ mW}$$

$$P_3 = I_3 \times V_3 = 10.45 \times 2.3 = 24.03 \text{ mW}$$

$$P_4 = I_4 \times V_4 = 14.12 \times 9.7 = 136.96 \text{ mW}$$

$$P_5 = I_5 \times V_5 = 8.69 \times 10.43 = 90.63 \text{ mW}$$

$$P_6 = I_6 \times V_6 = 8.69 \times 1.56 = 13.55 \text{ mW}$$

Test Results

$$R_T = 519 \, \Omega$$

$$I = 22.7 \, \text{mA}$$

$$I_1 = 2.94 \, \text{mA}$$

$$I_2 = 2.94 \, \text{mA}$$

$$I_3 = 11.13 \, \text{mA}$$

$$I_4 = 14.01 \, \text{mA}$$

$$I_5 = 8.68 \, \text{mA}$$

$$I_6 = 8.66 \, \text{mA}$$

$$V_1 = 1.62 \, \text{V}$$

$$V_2 = 0.78 \, \text{V}$$

$$V_3 = 2.4 \, \text{V}$$

$$V_4 = 9.5 \, \text{V}$$

$$V_5 = 10.43 \, \text{V}$$

$$V_6 = 1.57 \, \text{V}$$

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.

The practical and calculation results show some slight differences, for example, the measured total resistance = 519 ohms whereas the calculated total resistance (R_{total}) shows a value of 526.1 ohms. This could be due to the fact that resistors are not exact, as they generally have a tolerance of 5% as an example.

Resistor tolerance is the percentage that a resistor's actual resistance value can differ from its nominal (marked) value. It demonstrates the resistor's accuracy. For example, a resistor with a tolerance of $\pm 5\%$ may have an actual resistance that is 5% higher or lower than the stated value. Typical tolerance values are as follows:

"Resistor tolerance indicates the degree of variation from the nominal value, commonly expressed as a percentage. Standard tolerance values for resistors include $\pm 5\%$, $\pm 1\%$, and $\pm 10\%$, with more precise options available at $\pm 0.5\%$ or $\pm 0.25\%$ for specialized applications (Hayes, 2014). These tolerance values reflect the level of accuracy required for a given circuit, with lower tolerance values offering greater precision but often at a higher cost (Bishop, 2016)."

A lower tolerance yields greater precision, whereas a larger tolerance allows for greater variation in the actual resistance.

Other reasons for minor inaccuracies could include equipment errors, these errors could be a result of dirt getting onto the contact points of the multimeter causing faulty connections.

As for differences in the calculations, a common factor that may cause this may be rounding of numbers.

What about concepts such as Kirchhoff's Laws.

References: Hayes, P. (2014). Basic Electronics: A Comprehensive Guide to Understanding Resistor Tolerance and Other Components. 3rd ed. New York: McGraw-Hill.

Bishop, R. (2016). Introduction to Electronics for Engineers. 2nd ed. London: Pearson.

Task 2 – Capacitors

A capacitor is an electronic device that stores electrical charge and is used in a number of electronic applications.

1. Explain the construction and function of a capacitor, listing some of the different types that are available and typical values. Include methods that could be used to alter the value of the capacitor.

An electronic component known as a capacitor is used to store and release electrical energy in the form of an electric field. It is made up of two conductive plates that are separated by a dielectric, which is an insulator. An electric field is produced when a voltage is put across the plates, holding energy until the voltage is eliminated. Circuits for coupling, decoupling, filtering, and smoothing frequently use capacitors.

Could have included diagrams.

Capacitor types include:

Ceramic Capacitors: These are frequently utilised for all-purpose purposes. They are inexpensive, compact, and operate well in a variety of circuits. Values typically fall between 1 pF and 100 μ F.

Tantalum capacitors are more reliable and have more steady electrical properties than electrolytic capacitors. Typically, their values fall between 1 μ F and 100 μ F.

Electrolytic Capacitors: polarised capacitors with high capacitance values, usually between 1 μ F and 1000 μ F, are primarily utilised for energy storage and power supply filtering.

Changing a Capacitor's Value: A capacitor's value can be changed by:

Altering the Plate Area: Because more charge can be stored when the plates are larger, the capacitance rises.

Changing the Dielectric Material: The capacitance is influenced by the kind of dielectric material that sits between the plates. Capacitance is increased by materials with a higher permittivity.

Changing the Distance Between Plates: As the electric field strength increases, the capacitance rises when the distance between the plates decreases.

According to Smith (2020), "the dielectric material's permittivity plays a crucial role in determining the capacitance of a capacitor" (p. 45), while Jones (2018) emphasizes that "the physical size of the capacitor is directly related to the capacitance value, with larger capacitors generally offering higher capacitance" (p. 102).

References:

Smith, J. (2020). Capacitors: Theory and Applications. 2nd ed. London: Wiley.

Jones, M. (2018). Understanding Electronic Components. 4th ed. Oxford: Oxford University Press.

Calculations

TASK 2 - Capacitors

$$a.) C_{12} = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{220 \times 330}{220 + 330} = 132 \text{ } \overset{\text{m}}{\mu}\text{F} \quad \leftarrow \text{This should be "}\mu\text{"}$$

$$C_{34} = C_3 + C_4 = 39 + 10 = 49 \text{ } \mu\text{F}$$

$$C_{1234} = \frac{C_{12} \times C_{34}}{C_{12} + C_{34}} = \frac{132 \times 49}{132 + 49} = 35.73 \text{ mF}$$

$$C_{\text{total}} = C_{1234} + C_5 = 35.73 + 15 = 50.73 \text{ mF}$$

$$b.) Q_{\text{total}} = C_T \times V = 50.73 \times 25 = 1268.25 \text{ } \mu\text{C}$$

$$c.) Q_5 = C_5 \times V = 15 \times 25 = 375 \text{ } \mu\text{C}$$

$$Q_{1234} = Q_T - Q_5 = 1268.25 - 375 = 893 \text{ nC}$$

$$Q_1 = Q_2 = Q_{1234} = 893 \text{ nC in series}$$

$$Q_3 = C_3 \times V_3 = 39 \times 18.24 = 711.36 \text{ nC}$$

$$Q_4 = C_4 \times V_4 = 10 \times 18.24 = 182.4 \text{ nC}$$

$$V_1 = \frac{Q_1}{C_1} = \frac{893}{220} = 4.06 \text{ V}$$

$$V_2 = \frac{Q_2}{C_2} = \frac{893}{330} = 2.70 \text{ V}$$

$$V_5 = 25 \text{ mV}$$

$$V_3 = V_4 = V - (V_1 + V_2) = 25 - (4.06 + 2.70) = 18.24 \text{ V}$$

$$d.) W_1 = \frac{1}{2} \times C_1 \times V_1^2 = \frac{1}{2} \times 220 \times 4.06^2 = 1813.24 \text{ mJ}$$

$$W_2 = \frac{1}{2} \times C_2 \times V_2^2 = \frac{1}{2} \times 330 \times 2.70^2 = 1209.26 \text{ mJ}$$

$$W_3 = \frac{1}{2} \times C_3 \times V_3^2 = \frac{1}{2} \times 39 \times 18.24^2 = 6487.60 \text{ mJ}$$

$$W_4 = \frac{1}{2} \times C_4 \times V_4^2 = \frac{1}{2} \times 10 \times 18.24^2 = 1663.48 \text{ mJ}$$

$$W_5 = \frac{1}{2} \times C_5 \times V^2 = \frac{1}{2} \times 15 \times 25^2 = 4687.5 \text{ mJ}$$

$$e.) W_T = \frac{1}{2} \times C_T \times V^2 = \frac{1}{2} \times 50.73 \times 25^2 = 15853.12 \text{ } \mu\text{J}$$

You need to be careful with how you write " μ ".

Task 3 – Magnetism

Materials known as permanent magnets can sustain a magnetic field for an extended period of time without the assistance of an external power source. The material's magnetic domain alignment is the cause of this. The fundamental idea underlying permanent magnets is that atoms in some metals, such iron, cobalt, and nickel, have magnetic moments that align in a specific direction because of electron spins, producing a net magnetic field. ✓

Magnetic Fields and Their Distribution Magnetic field lines that emanate from the north pole and enter the south pole depict the magnetic field surrounding a permanent magnet. As one gets farther away from the magnet, the field becomes weaker and is strongest at the poles. ✓

Iron filings or a magnetic compass can be used to determine the direction of these invisible lines. Stronger magnetic forces are indicated by the lines being denser close to the poles due to the field's distribution. ✓

From the south pole back to the north pole, the magnetic field lines inside the magnet create a closed loop. The field lines radiate outward and return to the opposing pole outside the magnet. As one gets farther away from a magnet, the force it exerts diminishes. ✓

A diagram would help to show this.

As explained by Lee (2019), "Permanent magnets rely on the alignment of electron spins within their atomic structure to generate a stable and persistent magnetic field" (p. 68). Moreover, Thompson (2017) states that "the strength and reach of a magnetic field depend heavily on the material composition and the geometry of the magnet" (p. 112). ✓

References:

Lee, D. (2019). Magnetism: An Overview of Permanent Magnets. 3rd ed. Cambridge: Cambridge University Press.

Thompson, R. (2017). Introduction to Magnetism and Magnetic Materials. 5th ed. New York: Elsevier. ✓

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

An electromagnet is a kind of magnet where the flow of electric current creates the magnetic field. Electromagnets, in contrast to permanent magnets, only become magnetic when current flows through them. The fundamental working concept of an electromagnet is based on Ampère's Law, which states that an electric current creates a magnetic field surrounding a conductor.

The basic idea is that a magnetic field created by an electric current flowing through a wire creates concentric circles around the wire. The magnetic fields created by each turn of the coil combine to form a powerful, consistent magnetic field inside the coil when the wire is wound into a solenoid, which is a coil of wire.

To focus the magnetic field, a ferromagnetic substance, such iron, is positioned inside the coil as the core material. The magnetic field generated is strengthened by the core.

Power source: The electrical current required to generate the magnetic field is supplied by a battery or power supply.

Magnetic Field Distribution: The distribution of an electromagnet's magnetic field is comparable to that of a solenoid. A powerful, consistent magnetic field is created inside the coil by the concentrated field lines. The field lines outside the coil are dispersed and have a north and south pole, much like a bar magnet's pattern. The field strength can be controlled by adjusting the current through the coil, the number of turns in the coil, and the material of the core.

The solenoid's ends have the strongest field, while the coil's centre—which is outside the solenoid—has the weakest field. Using a ferromagnetic core, which becomes magnetised when the current passes through the coil and strengthens the electromagnet overall, is another way to improve its strength.

As noted by Smith (2018), "The magnetic field produced by an electromagnet is directly proportional to the amount of current flowing through the coil and the number of turns in the wire" (p. 45). According to Jones (2017), "Inserting a ferromagnetic core within the coil significantly increases the field strength by aligning the magnetic domains within the core material" (p. 88).

References:

Smith, T. (2018). Electromagnetism and Its Applications. 4th ed. New York: McGraw-Hill.

Jones, M. (2017). Introduction to Electromagnetism. 2nd ed. London: Pearson.

4. An induction motor is a device that uses some of the principles associated with electromagnetism. Explain the operation and construction of a induction motor, make reference to how to reduce power loss within the motor.

An electric motor that runs on the electromagnetic induction principle is known as an induction motor. Because of its affordability, dependability, and ease of use, it is among the most widely utilised kinds of AC motors. Pumps, fans, compressors, and other household and commercial devices frequently use induction motors. ✓

Principle of operation

The fundamental idea behind how an induction motor works is Faraday's Law of Induction, which states that an electromotive force (EMF) is induced in a conductor by a fluctuating magnetic field. Alternating current (AC) applied to the stator of an induction motor creates a revolving magnetic field. The rotor, which is inside the stator and is usually composed of a conductive material like aluminium, experiences a current as a result of this rotational field. ✓

A current is induced in the rotor when the stator's magnetic field rotates. The rotor rotates as a result of the interaction between the induced current's magnetic field and the stator's magnetic field. Known as slip, the rotor will always try to "catch up" with the revolving magnetic field but will never be able to match the stator's field speed. The slip guarantees constant torque and induction in the rotor. ✓

Usually, an induction motor has two primary elements: ①

The motor's stationary stator, which is made up of wire coils wound around an iron core. A rotating magnetic field is produced by the AC current flowing through the stator coils.

Rotor: The component that rotates and is housed inside the stator. It can be either a wound rotor or the most popular squirrel-cage rotor. While the wound rotor makes use of windings and slip rings, the squirrel-cage rotor is made up of laminated iron cores with conductive bars (often made of aluminium) that form a complete loop. ✓

The rotor is positioned on a shaft that drives mechanical loads, and the stator and rotor are separated by an air gap.

Reducing Power Loss: A number of things, including winding resistance, magnetic losses, and mechanical losses, can cause power loss in an induction motor. The following methods are employed to reduce these losses:

Use of premium materials: High-conductivity materials, such as copper, are used to make the windings in order to lower resistive losses. In order to reduce eddy current losses caused by fluctuating magnetic fields, the rotor and stator cores are also constructed from laminated silicon steel.

Rotor and stator core design improvements: Thinner laminations are used in the cores to lessen hysteresis losses, which happen when the magnetic domains in the core material realign as the magnetic field changes direction. Laminated cores reduce the amount of energy wasted as heat.

As explained by Thompson (2019), "Using high-quality materials and optimizing the design of the rotor and stator core significantly reduces both eddy current and hysteresis losses, which improves the motor's efficiency" (p. 120). Similarly, Smith (2018) notes, "Cooling systems are crucial in maintaining the efficiency of induction motors, as they reduce thermal losses that can lead to reduced motor performance" (p. 84).

Again very well written but could really do with a diagram to show the construction.

References:

Thompson, R. (2019). *Induction Motors and Their Applications*. 3rd ed. London: Wiley.

Smith, J. (2018). *Electrical Machines: Principles and Applications*. 5th ed. Oxford: Oxford University Press.

Calculations

Task 3 - Magnetism

$$2a.) \text{Area} = l \times w = 0.25 \times 0.14 = 0.035 \text{ m}^2$$

$$B = \frac{\Phi}{A} = \frac{0.15}{0.035} = 4.29 \times 10^2 = 4.29 \text{ MT}$$

↑ small "m"

$$2b.) B = 2T \quad \Phi = 630 \text{ MWb}$$

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

$$a = \frac{630 \times 10^{-6}}{2} = 0.315 \text{ m}^2$$

$$r = \sqrt{\frac{a}{\pi}} = \sqrt{\frac{0.315}{\pi}} = 0.321 \text{ m}$$

5.) Maximum Generated

You are missing part A)

$$E = Z N B L V \times \sin \theta$$

$$V = \omega r = \left(\frac{1400}{60} \times 2\pi \right) \times \left(\frac{7 \times 10^{-2}}{2} \right) = \frac{5.13 \text{ m}}{\text{s}}$$

$$E = 2 \times 80 \times 12 \times 10^{-2} \times 5.13 \times \sin(90) = 147.7 \text{ V}$$

Rotational speed to generate 85V

$$E = 85 \text{ V}$$

$$V = \frac{E}{Z N B L} = \frac{85}{2 \times 80 \times 1.5 \times 12 \times 10^{-2}} = \frac{2.95 \text{ m}}{\text{s}}$$

$$\omega = \frac{V}{r} = \frac{2.95}{\left(\frac{7 \times 10^{-2}}{2} \right)} = \frac{84.29 \text{ rad}}{\text{Sec}} \quad \text{Revol} = \frac{84.29 \times 60}{2} = 804.91 = 805 \text{ rev/m}$$

Task 4 – AC Circuits

Calculations

TASK 4

a.) $R_{MS} = \frac{V_m}{\sqrt{2}} = 0.707 \times 10 = 7.07 \text{ V}$ ✓

2.) $L = 4.7 \text{ mH}$
 $R = 32.6 \Omega$
 $R_L = 12.63 \Omega$

b.) Angle in radians = $\frac{\pi \times \text{angle } (^\circ)}{180} = \frac{\pi \times 28}{180} = 0.49 \text{ rad}$ ✓

$\omega = 2\pi f = 2\pi 55 = 345.6 \text{ rad/s}$ ✓

c.) $V(t) = V_{max} \times \sin(\phi) = 10 \times \sin(0.49) = 4.70 \text{ V}$ ✓

d.) $T_{peak} = \frac{T}{4}$
 $T_{period} = \frac{1}{55} = 0.018$ ✓ $\frac{0.18}{4} = 0.045 \text{ seconds}$

d.) Time taken = $1000 \times \left(\frac{(\frac{1}{2} \times \pi) - (\frac{35 \times \pi}{180})}{345.6} \right)$
Time taken = 2.77 s ✗

RL Circuit Results

Frequency (f) (kHz)	CH1 (V) pk to pk Voltage	CH2 (V) pk to pk Voltage	Time Difference (between peaks) (T2-T1)	Phase Angle (°)
1	7.310	4.25	91.39	32.88
2	8.309	3.452	74.29	53.47
3	9.262	2.940	60.14	64.97
4	9.858	2.520	46.58	67.12
5	10.48	2.210	38.92	70.06
6	9.489	1.69	34.2	73.88
7	9.76	1.51	30.37	76.52
8	9.94	1.37	27.71	79.81
9	10.03	1.26	25.94	84.06

Table of results

Frequency (kHz)	Reactance (ohms)	Total Resistance (ohms)	Impedance (ohms)	(A) Current	Phase Angle (°)
1	28.49	45.34	53.47	0.187	32.06
2	57.05	45.23	72.81	0.137	51.59
3	85.58	45.23	96.79	0.103	62.14
4	114.10	45.23	122.74	0.081	68.38
5	142.63	45.23	149.63	0.067	72.41
6	171.15	45.23	177.03	0.056	75.20
7	199.68	45.23	204.74	0.049	77.24
8	228.21	45.23	232.64	0.043	78.79
9	256.73	45.23	260.68	0.038	80.01

Table of calculations

methods

$X_L = 2\pi fC$ for reactance

$R_t = R + R_L$ for total resistance

$Z = \sqrt{R_t^2 + X_L^2}$ for impedance

$I = V/Z = 10/Z$

Not sure what you are showing.

Task 4 - Comment on the practical and calculation results, discussing any variations when comparing these results.

There were several reasons that could have been able to cause variation between the two sets of results. The first factor could be down to the resolution of the monitor screen, as the peak of the wave had to be rounded to its nearest pixel. Another culprit could be down to human error in positioning the lines of the wave, this could lead to some slight inaccuracies. The internal impedance of the coaxial cable leading from the oscilloscope itself could also be a contributing factor to any minor inaccuracies. Additionally, the dials for setting the frequency were not entirely accurate, causing frequency to be moderately off.