

2024583

by Harri Jones

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Name: Harri Jones
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1. Executive summary

what about your research?

This assignment provides an analysis of single-phase transformers and three-phase induction motors. The analysis of the single-phase transformer includes applying different loads to the transformer, with this the voltage regulations and efficiency were calculated and compared with simulated and practical values. Open and short circuit tests were carried out to determine the approximate equivalent circuit parameters. The analysis of the three-phase induction motor includes stator resistance, no-load and blocked-rotor tests, the performance of the motor was then produced on a spreadsheet. The main purpose of the report is to understand how these systems will work prior to running them by using the correct formulas and equations, this can give the engineer an understanding of which transformer or motor is suitable for the application.

The assignment finds that creating an equivalent circuit by performing open and short circuit tests will allow for the voltage regulation and efficiency to be predicted under certain loads. The simulation software used confirms this. The report also finds that carrying out the three tests for the induction motor will determine the approximate per phase equivalent circuit for the motor. Using a spreadsheet, a graph was created displaying the performance of the motor which includes the three different regions, motoring, generating and braking.

a good summary but contains repetition and says nothing about your research

2. Work plan for Life-long Learning

brief asked you to fully justify your text

The task will be approached by beginning with the Research to gain a better understanding of the subject and help giving a head start towards the practical tests. Safety measures will be followed at all times whilst carrying out the practical tests. After completing the practical, a conclusion and recommendations will be made at the end. A risk assessment was created prior to beginning the practical tests to underline the potential hazards in the workplace.

this is supposed to be a plan written in the future tense

Throughout the assignment a better understanding of how single-phase transformers perform and operate under different loads was achieved. Different methods of induction machine speed control methods were researched in order to gain an understanding of. The ability to create an approximate equivalent circuit was obtained by carrying out open and short circuit tests in order to obtain the circuit parameters. With the circuit, voltage regulation and efficiency were calculated and compared with measured and simulated results. It was also understood during the assignment how important a simulation software would be, as it allowed the calculations to be compared and confirm whether they were correct or not.

Performing practical tests on a three-phase induction motor had aiding in gaining a better understanding of how they operate, and how their performance can be predicted by carrying out the correct equations. The performance was then able to be shown on a graph by using a spreadsheet which allowed the ability to view the three different regions.

this reads like a conclusion not a plan

3. Research

3.1 Phase angle control

Phase angle control is a method of controlling the amount of supplied power to an electrical load, this occurs by changing the load's applied voltage phase angle. This is achieved by adjusting the thyristors firing angle (a type of semiconductor device) that is used as a switch to control the electrical power flow. Adjusting the thyristors firing angle allows the thyristor to control the amount of supplied power to the load therefore allowing the phase angle of the voltage applied to the load to be controlled. This method is commonly found in power electronics applications, for example lighting control and motor control. (Das, 2020)

phase voltage not phase angle
the angle is the firing angle of the thyristors
not quite correct
phase angle between voltage and current is not the same as the delay angle alpha for the thyristor

$$T = sV^2$$

The equation above shows that when the supply voltage is reduced the torque will drop. If the voltage is lowered for a given load the speed will reduce to maintain the load torque constant and the slip will increase. The voltage can be lowered to a suitable value and if the voltage is lowered beyond this value the motor will become unstable. This method of speed control is uncommon as it can result in an overheated motor due to the minor change in speed demands a voltage reduction. (Parasher, 2021) Correctly cited

3.2 Quasi-Square Wave Inverter

A Quasi-Wave is generated in a three-phase inverter bridge (see figure 9) by having the transistors switch on and off in a specific sequence depending on what degree the transistors are on for (see figure 10). To eliminate the potential problem of having two in series transistors on simultaneously the transistors will only switch for 120 degrees. Switching for only 120 degrees has a disadvantage that the waveforms and voltage regulation are dependent on the load power factor. (V.Guynes, 1977) *surname only in citation*

The inverter input voltage of the Q-S must be adjustable however the harmonic content of the wave is invariable. If an induction motor below 5Hz were powered by a Q-S inverter the drive would be unstable at low speeds due to the harmonic torques. As it is unsuitable for this operation, a pulse width modulation (PWM) system would be used. The Q-S inverter output can be tolerated at higher frequencies however due to the fast-switching devices PWM is commonly used instead. (Lander, 199) Correctly cited

good

3.3 Cycloconverter

Cycloconverters use frequency to convert the AC power of a specific voltage and frequency to a different voltage and frequency of AC power without an intermediate DC Link. (Heydt, 2005) A naturally commutated converter where the voltage and output frequency can be controlled continuously and independently. (Blaabjerg, 2018) Correctly cited

why 18?

A three pulse cycloconverter contains 18 thyristors which feeds a three-phase load (see figure...). The cycloconverter thyristors are naturally commutated and depending on whether the load is capacitive, inductive or resistive the firing of the thyristors needs to be delayed in order to shape the output, resulting that the input current supplied will always lag its associated voltage. Figure 12 shows the load voltage waveforms produced by the cycloconverter, the waveforms have a lagging power factor load. The waveforms show that having a higher pulse number will give an output waveform closer to the desired sinusoidal waveform. (Lander, 1994) Correctly cited

3.4 Flux Vector Control

Flux vector control is a control technique in AC drives which controls the speed and torque of the motor. The stator flux and rotor flux are manipulated, this controls the motor rather than the frequency and voltage of the power supply. Doing this allows for the control of the motors speed and torque to be more precise, even at lower speed which can also improve the overall performance and efficiency of the motor. (Cadence Systems, 2017) A control algorithm is used to measure the rotor flux and adjust the stator flux to control the motors speed and torque. This control technique is usually found in high performance control applications for example electric vehicles and robotics. (K, 2006) Punctuation Error
surname?

3.5 Power Systems

A power system is required to supply factories containing induction machines with three-phase AC supply. Electricity is generated via power plants, by using various methods for example, nuclear, natural gas, coal, or renewable energy sources. This electricity generated is transmitted through high voltage transmission lines to substations situated near the factories. The substations contain step down transformers which lower the voltage to a more suitable level for distribution to the factory. (Daware, 2020) The lines used are medium voltage distribution lines. (NationalGrid, 2022) The lines are then distributed to the factories switchgear such as switches and circuit breakers to control and protect the electrical systems. The power

from the switchgear is then sent to the distribution boards of the factory where it can be distributed across the factory to different sectors. Within these sectors are motor control centres which are required to control and protect the induction motors. (ElectricalTechnology, 2020) Industries such as steel manufacturers require transformers to ensure appropriate and safe use of power supply, which can prevent the cause of unnecessary power issues. (Servomax, 2019) Correctly cited

The most suitable supply voltage for induction motor applications depends on which specific application and size motor is being used. Three-phase induction motors commonly use voltages such as 230V or 415V. (Tempo Automation, 2017) In industry it is common that a higher voltage is used for the motor to reduce the energy loss in the electrical distribution system. It is important for motors to use to correct voltage to prevent damage from occurring and ensure optimal performance. (DukeElectric, 2021) ???

4. Transformer Investigation

4.1 Introduction

Open and short circuit tests were carried out on the single-phase transformer. Health and Safety precautions were carried out prior to the testing. The transformer is isolated, requiring a key to operate. Correct PPE was always worn, in this case safety glasses due to the shaft of the motor being exposed and rotating at high speeds. ^{power analyser} A multimeter was used to gain and monitor the values these were then used to calculate the parameters for the equivalent circuit.

4.1.1 Open Circuit Test ^{2:1}

A single-phase transformer with a 1:2 turns ratio was connected to a 230V, 50Hz supply.

The voltage, input power and input voltage were measured. (See appendix 9.2.1)

With the measured values, the power lost equation can be rearranged to find the open circuit resistance which is responsible for the core losses 'Rc'. (See appendix 9.2.2)

With the 'Rc' value obtained, the current which supplies the core losses 'Ic' can then be found by using Ohm's law. (See appendix 9.2.3)

The magnetising current 'Im' can then be found. Ohm's law can then be used to find the reactance of the core 'Xm'. (See appendix 9.2.4)

The values obtained were placed in to multisim (See appendix 9.2.5)

The measured values and simulated values were then placed in a table (see figure 1)

Open Circuit Test		
	Measured	Simulated
V1	230.8V	230.8V
I1	0.55A	0.68A
Pin	28.8W	28.8W

what were your values of Rc and Xm?

Figure 1 - Open Circuit Comparison Table

Looking at figure 1, the values obtained from the simulated are identical besides from the primary current which has a 0.13A difference.

4.1.2 Short Circuit Test

In this test the core losses are eliminated, and the windings are isolated. This is to determine the total equivalent resistance and total equivalent reactance ' R_{1E} ' & ' X_{1E} ' if referring to primary equivalent referred values or ' R_{2E} ' & ' X_{2E} ' if referring to secondary referred values.

The primary voltage, primary current, input power and secondary current were measured. (See appendix 9.3.1)

Calculating the primary equivalent impedance, resistance and leakage reactance (See appendix 9.3.2)

The secondary equivalent impedance, resistance and leakage reactance can be calculated using the primary values recently obtained. (See appendix 9.3.3)

The secondary current was already measured at 3.48A however this can also be calculated. (See appendix 9.3.4)

The values obtained were placed in to multisim. (See appendix 9.3.5)

A table was then created to compare the measured and simulated values. (See figure 2)

what were your values of R_{1E} and X_{1E} ?

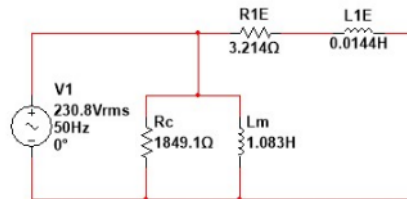
Short Circuit Test		
	Measured	Simulated
V1	9.4V	9.4V
I1	1.69A	1.69A
I2	3.48A	3.432A
Pin	9.18W	9.230W

Figure 2 - Short Circuit Comparison Table

Looking at figure 2, the results are very similar with minor differences. The multisim value of I2 was 1.716A however due to the turns ratio being 1:2 this value can be multiplied by 2 to achieve 3.432A

4.1.3 Equivalent circuit

With the values obtained from the two tests an equivalent circuit can be created. (See figure 3)



the load should be as this diagram shows a short circuited secondary

Figure 3 - Equivalent Circuit

4.2.1 R Circuit

Values were obtained from the measuring equipment. (See appendix 9.4.1) The resistance was set to 48.2Ω .

The voltage regulation is the change in the output voltage V2 between no load and full load for a given load power factor. See appendix 9.4.2 for calculations.

Load Test 1		
	% Regulation	% Efficiency
Calculated	1.57%	88.73%
Simulated	1.55%	N/A
Practical	1.57%	87.71%

Figure 4 - Load Test 1

4.2.1 RL Circuit

Values were obtained from the measuring equipment. (See appendix 9.4.3) The resistor was set to 20Ω , and the inductor was 85mH .

See appendix 9.4.4 for calculations.

Load Test 2		
	% Regulation	% Efficiency
Calculated	3.77%	84.29%
Simulated	3.99%	N/A
Practical	3.68%	83.48%

Figure 5 - Load test 2

what do these results prove?

4.2.2 RC Circuit

Values were obtained from the measuring equipment. (See appendix 9.4.5) The resistor was set to $20.27\ \Omega$ and the capacitor was set to $48.18\mu\text{F}$

See appendix 9.4.6 for calculations.

Load Test 3		
	% Regulation	% Efficiency
Calculated	-1.11%	63.30%
Simulated	-1.12%	N/A
Practical	-1.23%	75.00%

Figure 6 - Load Test 3

4.2.3 Percent regulation and efficiency comparison

Looking at figure 4,5 and 6, the percent regulations are all very similar. Load test 1 had a difference of 0.02% whilst the calculated and simulated were matching, this could have been a rounding error on the software used. Load test 2 had the largest percent regulation difference at 0.31%. This could be due to rounding of the values, or perhaps taking an incorrect reading on the multimeter used in the practical. Load test 3 had a difference of -0.12%, this could be due the same reasons as load test 2. The percent regulation was negative meaning that the voltage was increasing with the load.

From the three load tests, all of the percent efficiencies were relatively similar besides from load test 3 which had a difference of 11.7%, this could possible be due to a calculation error. The calculated efficiency should be more accurate rather than the practical as the calculation contains values such as the winding resistances and leakage reactance's.

what do the results mean?

5. Three-phase Induction Motor Investigation

5.1. Introduction

Three tests were carried out on the three-phase induction motor, stator resistance, no-load and blocked rotor tests. Health and safety measures were taken throughout the testing, correct PPE was worn at all times. The multimeter was used to measure the power, voltage, current and power factor. A tachometer was used to measure the rpm of the motor. The torque was measured with a gauge on the motor.

5.1.1 Stator resistance test

For the stator resistance test, the rotor was locked, and dc was applied to the stator, the current and voltage measurements were then used to calculate the resistance.

The resistance per phase was 34.25Ω .

5.1.2 No Load test

For the no-load test a variable speed drive was coupled and driven at synchronous speeds before applying the rated voltage to the stator.

Line Voltage	124V	Phase 1	8W
Line Current	.56A	Phase 2	8W
Total Power	25W	Phase 3	8W

With the no load test results, the per phase values can be calculated. (See appendix 9.5.1)

Due to the stator being connected in delta the measurements had to be $\times \sqrt{3}$.

5.1.3 Blocked rotor test

For the blocked rotor test the rotor is stopped from turning with a low voltage being applied to the stator so rated current flows.

Line Voltage	103V
Line Current	1.95A
Total Power	303W

With these blocked rotor test results the per phase values can be found. (See appendix 9.5.2)

5.1.4 Equivalent Circuit

With the values obtained from the 'No load' and 'Blocked rotor' tests an equivalent circuit can be made. (See figure 7)

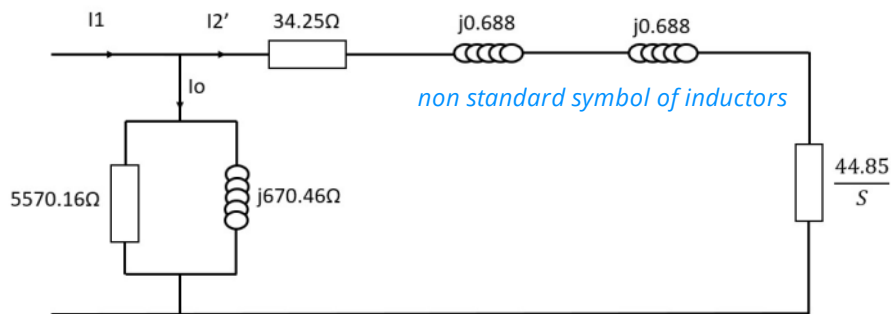


Figure 7 - Equivalent circuit

5.2.1 Motor performance

With the circuit parameters a spreadsheet was produced showing the torque and stator current of the motor over a range of speeds. (See appendix 9.5.3)

A more detailed graph was then created showing the 'Tmax' and the three regions. (See figure 8)

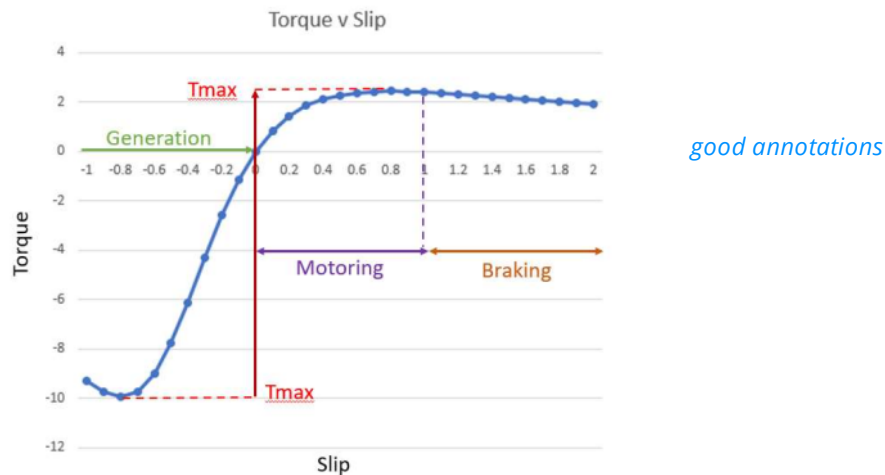


Figure 8 - Torque v Slip Graph

Generating region – The induction motor is acting as a generator due to the speed increasing higher than the stator rotating magnetic field. When the rotational speed is greater than the

rotating magnetic field speed, the slip becomes negative $s < 0$ along with the torque being negative. In this case the torque begins at -9.3 before reaching the motoring region at $s = 0$.

Motoring region – Due to the slip being less than 1, the speed of the rotor is now less than synchronous speed. The rotor is now rotating in the direction of the rotating magnetic field. The torque varies from 0 to full load torque (2.432) as the slip varies also. When the slip value is 1 the rotor of the motor will be stationary (at 2.393).

Braking region – This is where the slip is more than 1 ($s > 1$). The rotor is revolving in the opposite direction of the rotating magnetic field.

5.3.1 Prediction

During the generating region the power becomes negative. Due to this the power factor will decrease along with the torque. A negative slip will produce a negative torque causing a braking effect.

power factor increases with torque

5.4.1 Inverter and Prony brake

A 4-pole induction motor was connected to an inverter and Prony brake. The stator voltage and rotor speed were measured. The frequency was increased in intervals of 5Hz until reaching 50Hz.

Before doing the tests, calculations were made to predict the expected values.

The synchronous speed can be calculated as:

$$N_s = f \left(\frac{2}{p} \right) \times 60$$

what was the relationship between V and f ?

See appendix 9.4.3 for synchronous speeds.

The speed of the rotor was measured with a laser tachometer and the voltage was measured with a multimeter (see appendix 9.5.4) for measurements. With these values the slip can be

calculated by using $S = \frac{N_s - N_r}{N_s}$ (see appendix 9.5.5 for calculated slip)

6. Conclusions and Recommendations

Research was carried out on different types of induction machine speed control methods such as phase angle control, quasi square-wave converter, cycloconverter and flux vector drive. The power systems required to deliver a three-phase AC supply to factories were also studied.

Throughout the assignment a better understanding of how single-phase transformers perform and operate under different loads was achieved. Different methods of induction machine speed control methods were researched in order to gain an understanding of. The ability to create an approximate equivalent circuit was obtained by carrying out open and short circuit tests in order to obtain the circuit parameters. With the circuit, voltage regulation and efficiency were calculated and compared with measured and simulated results. It was also understood during the assignment how important a simulation software would be, as it allowed the calculations to be compared and confirm whether they were correct or not.

Once again suitable measuring equipment was used to carry out stator resistance, no-load and block rotor tests. With these values the approximate per phase equivalent circuit was created. Excel was used to produce a spreadsheet to simulate the motor's performance. Using the torque and stator current obtained, a graph was produced to view the main regions of operation; motoring, generating and braking. An equivalent circuit was created to predict the performance of the motor under load, the motor was driven faster than synchronous speed using a VSD.

A recommendation would be to carry out practical tests on step down or step up transformers to gain a better understanding of how they work and how changing different parameters would affect the performance. ???

As a three-phase induction motor was used, a recommendation would be to perform tests on a single-phase induction motor to be able to see the difference and use formulas and calculations to predict the performance.

7. Team Working

brief asks for fully justified text format

Working as a team during the practical tests has allowed for the ability to pool different skills, knowledge and perspectives, resulting in more creative and innovative solutions. When working as a team, it is important to have a clear understanding of each team member's responsibilities. For example, during the three-phase induction motor task one member would be using the tachometer, one would be reading the voltage on the multimeter and the other would be writing the values down on excel. It is also important to have clear lines of communication to ensure that everyone is kept informed and that any issues can be addressed quickly.

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9. Appendix

Single-Phase Transformers and Three-Phase Induction Motors Risk Assessment

Company name: Coleg Sir Gar

Assessment carried out by: Harri Jones

Date of next review: 22/12/2022

Date assessment was carried out: 10/11/2022

What are the hazards?	Who might be harmed and how?	What are you already doing to control the risks?	What further action do you need to take to control the risks?	Who needs to carry out the action?	When is the action needed by?	Done
Slips/Trips/Falls	Operators/Engineers/Students	Bags and chair moved out of the operating area	If any trailing cables place trip mat over	CSG Engineering Department	Immediately	No
Injury by Motor Rotating	Operators/Engineers/Students	PPE – Safety Glasses to be worn	Place guarding around Motor	CSG Engineering Department	Immediately	No
Risk of Burns	Operators/Engineers/Students	E-Stops drop out the power	Place guarding around Motor	CSG Engineering Department	Immediately	No
Electric Shock	Students	E-Stops drop out the power	Covers over any exposed terminals	CSG Engineering Department	Immediately	No
Electric Shock	Engineers whilst carrying out maintenance	Maintenance to only be carried out by someone qualified	Maintenance to be carried out after doing safe isolation procedure	CSG Engineering Department	Immediately	No

9.1 – Appendix – Task 1

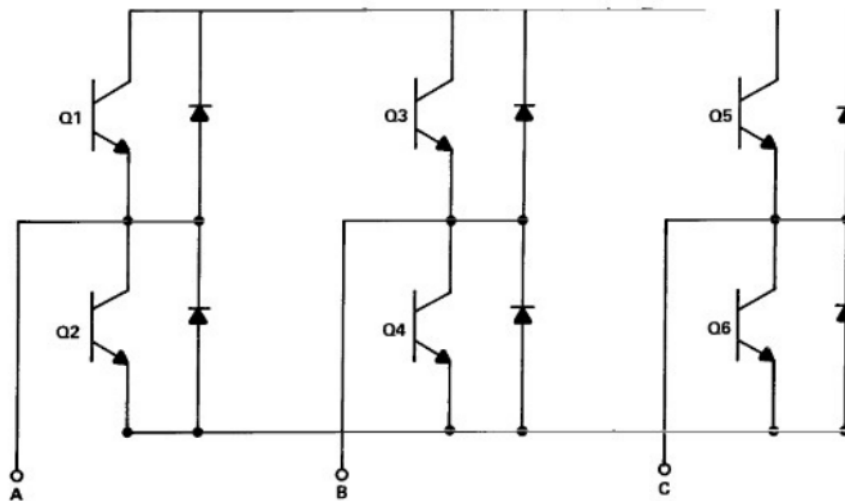


Figure 9 - Quasi Three phase inverter transistor bridge

Q	120° DRIVE						180° DRIVE							
1	1	1	0	0	0	0	1	1	1	0	0	0		
2	0	0	0	1	1	0	0	0	0	1	1	1		
3	0	0	1	1	0	0	0	0	1	1	1	0		
4	1	0	0	0	0	1	1	1	0	0	0	1		
5	0	0	0	0	1	1	1	0	0	0	1	1		
6	0	1	1	0	0	0	0	1	1	1	0	0		
Degrees	0	60	120	180	240	300	360	0	60	120	180	240	300	360

Figure 10 - Transistor switching schemes.

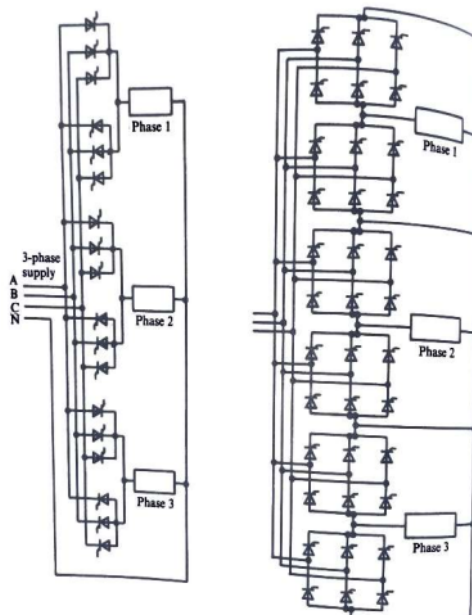


Figure 11 - 3 Pulse Bridge

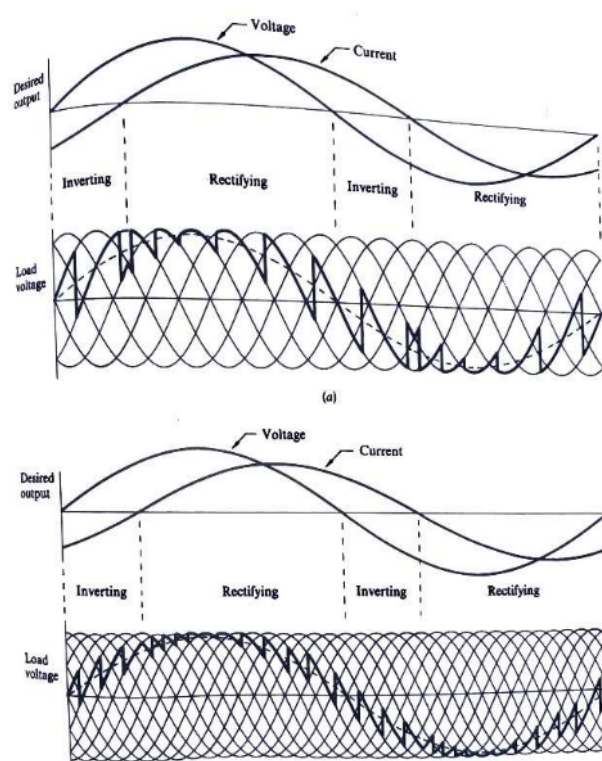


Figure 12 - 6 & 12 pulse connection

9.2.1

$$\text{Voltage} = 230.8\text{V}, \quad \text{Input Power} = 28.8\text{W}, \\ \text{Input current} = 0.55\text{A}$$

9.2.2

$$\text{Power Lost} = \frac{|V_1|^2}{R_c} \quad 28.8\text{W} = \frac{53268.64}{R_c}$$

This can be rearranged to find R_c

$$R_c = \frac{53268.64}{28.8} = 1849.6\Omega$$

9.2.3

$$|I_c| = \frac{|V_1|}{R_c} = \frac{230.8}{1849.6} = 124.48\text{mA}$$

9.2.4

$$\text{Since } |I_o| = \sqrt{|I_c|^2 + |I_m|^2}$$

$$\therefore |I_o|^2 = |I_c|^2 + |I_m|^2$$

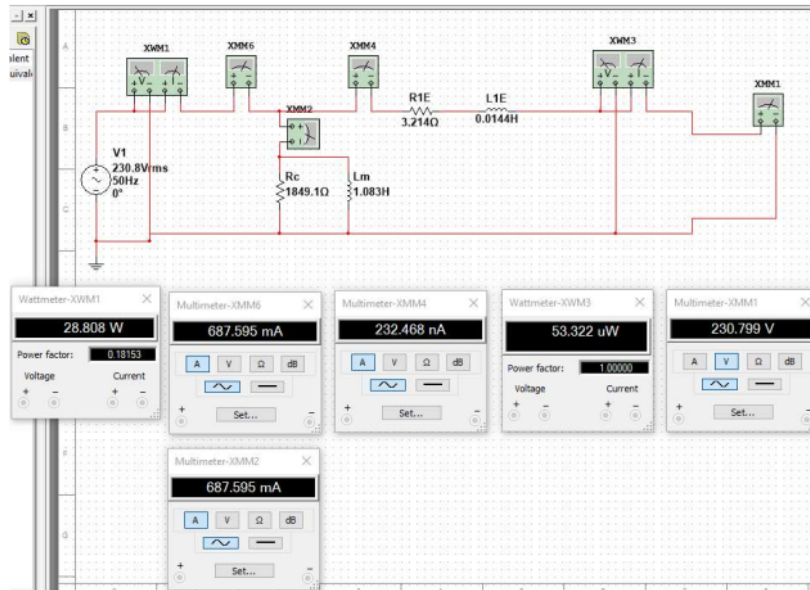
$$0.55^2 = 124.48^2 + |I_m|^2$$

$$|I_m|^2 = 0.3025 - 0.0155 = 0.287$$

$$|I_m| = \sqrt{0.287} = 0.5357\text{A}$$

$$X_m = \frac{|V_1|}{|I_m|} = \frac{230.8}{0.5357} = 430.8\Omega$$

9.2.5



9.3.1

$$\begin{array}{ll} \text{Primary Voltage} = 9.4\text{V} & \text{Input power} = 9.18\text{W} \\ \text{Primary Current} = 1.69\text{A} & \text{Secondary current} = 3.48\text{A} \end{array}$$

9.3.2

$$\begin{aligned} Z_{IE} &= \frac{V_1}{I_1} = \frac{9.4}{1.69} = 5.562\Omega \\ R_{IE} &= \frac{P_{IN}}{I_1^2} = \frac{9.18}{1.69^2} = 3.214\Omega \\ X_{IE} &= \sqrt{Z_{IE}^2 - R_{IE}^2} = \sqrt{5.56^2 - 3.214^2} = 4.539\Omega \end{aligned}$$

9.3.3

$$|Z_{2E}| = \left(\frac{N_2}{N_1}\right)^2 |Z_{1E}| = \left(\frac{110}{230}\right)^2 \times 5.562 = 1.27 \Omega$$

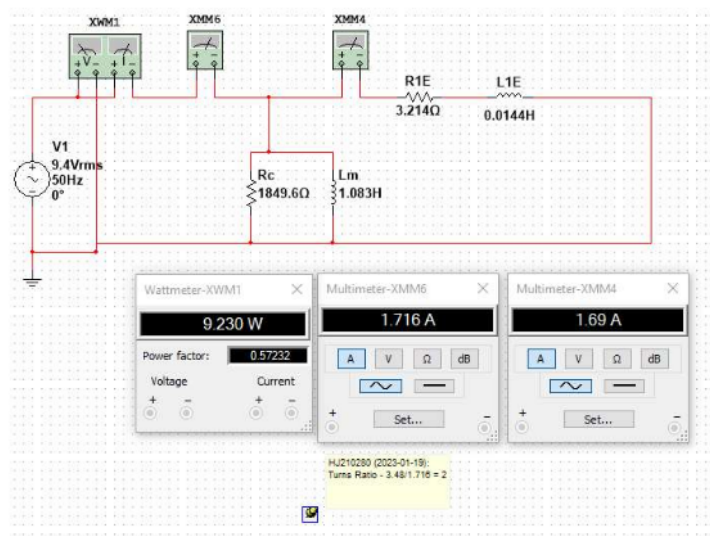
$$R_{2E} = \left(\frac{N_2}{N_1}\right)^2 |R_{1E}| = \left(\frac{110}{230}\right)^2 \times 3.214 = 0.735 \Omega$$

$$X_{2E} = \left(\frac{N_2}{N_1}\right)^2 |X_{1E}| = \left(\frac{110}{230}\right)^2 \times 4.539 = 1.038 \Omega$$

9.3.4

$$I_2 = \frac{N_1}{N_2} \times I_1 = \frac{230}{110} \times 1.69 = 3.53 \text{ A}$$

9.3.5



9.4.1 R

Load Test 1 R = 48.26Ω	
	Measured
V1	230.1V
I1	1.38A
V2	111.5V
I2	3.21A
Pin	292.1W
Pout	256.2W
P.f	1

9.4.2 R

Calculated

$$\% \text{ Reg} = \frac{I_2 (R_{2E} \cos \phi_2 + X_{2E} \sin \phi_2)}{V_2} \times 100$$

$$\% \text{ Reg} = \frac{2.31 (0.734 \times 0.499 + 1.038 \times 1)}{111.5} \times 100 = 1.52 \%$$

Simulated

$$\% \text{ Reg} = \frac{E_2 - V_2}{V_2} \times 100 = \frac{112.96 - 111.18}{111.18} \times 100 = 1.547 \%$$

Practical

$$\% \text{ Reg} = \frac{112.96 - 111.15}{111.15} \times 100 = 1.574 \%$$

9.4.3 RL

Load Test 2 RL = 31.5Ω, 85mH	
	Measured
V1	230V
I1	2.09A
V2	108.6V
I2	3.24A
Pin	210W
Pout	175.3W
P.f	0.499

9.4.4

Calculated

$$\% \text{ Reg} = \frac{3.24(0.734 \times 0.449 + 1.038 \times 0.86)}{108.6} \times 100 = 3.77 \%$$

Simulated

$$\% \text{ Reg} = \frac{112.6 - 108.2875}{108.2875} \times 100 = 3.985 \%$$

Practical

$$\% \text{ Reg} = \frac{112.6 - 108.6}{108.6} \times 100 = 3.683 \%$$

9.4.5 RC

Load Test 3 RC = 20.27Ω, 48.18uF

	Measured
V1	229.8V
I1	0.47A
V2	114V
I2	1.65A
Pin	80W
Pout	60W
P.f	0.737

9.4.6

Calculated

$$\% \text{ Reg} = \frac{1.65(0.734 \times 0.3 + 1.038 \times 0.9539)}{114} \times 100 = -1.11 \%$$

Simulated

$$\% \text{ Reg} = \frac{112.6 - 113.87}{113.87} \times 100 = -1.12 \%$$

Practical

$$\% \text{ Reg} = \frac{112.6 - 114}{114} \times 100 = -1.228 \%$$

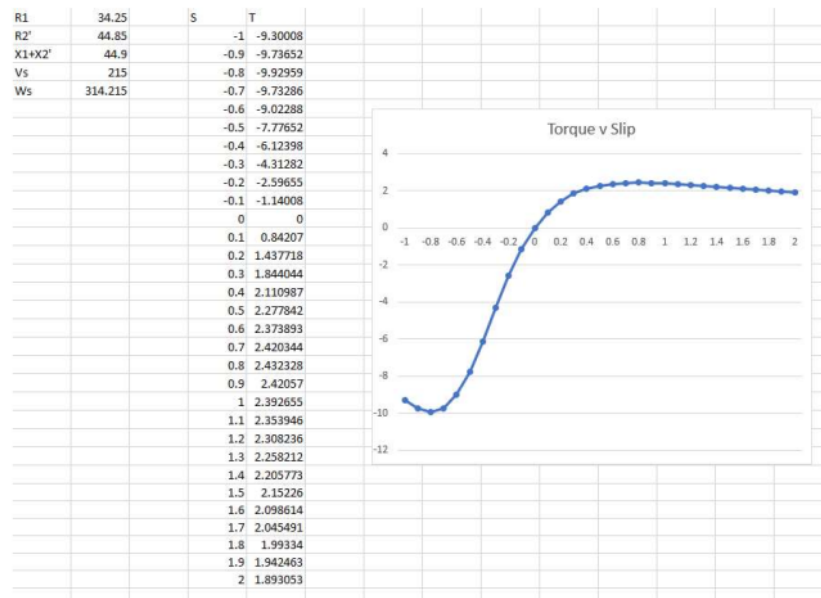
9.5.1

$$\begin{aligned}
 V_0 &= 124 \times \sqrt{3} = 215 \text{ V/phase} \\
 I_0 &= \frac{0.56}{\sqrt{3}} = 0.323 \text{ A/phase} \\
 P_0 &= \frac{25}{3} = 8.3 \text{ W/phase} \\
 \therefore \cos \phi_0 &= \frac{P_0}{V_0 I_0} = \frac{8.3}{215 \times 0.323} = 0.1195 \\
 \therefore \phi_0 &= 83.17^\circ \\
 \therefore R_c &= \frac{V_0}{I_0 \cos \phi_0} = \frac{215}{0.323 \times 0.1195} = 5570.16 \Omega \\
 X_m &= \frac{V_0}{I_0 \sin \phi_0} = \frac{215}{0.323 \times 0.99} = 670.46 \Omega
 \end{aligned}$$

9.5.2

$$\begin{aligned}
 V_L &= 103 \text{ V} \\
 P_0 &= 303 \text{ W}, \quad 303 \div 3 = 101 \text{ W} \\
 I_L &= 1.95 \div \sqrt{3} = 1.13 \text{ A/phase} \\
 V_{sc} &= 103 \text{ V/phase} \\
 I_{sc} &= 1.13 \text{ A/phase} \\
 P_{sc} &= 101 \text{ W/phase} \\
 \therefore \cos \phi_{sc} &= \frac{P_{sc}}{V_{sc} I_{sc}} = \frac{101}{103 \times 1.13} = 0.8678 \text{ Lagging} \\
 \therefore \sin \phi_{sc} &= 0.4902 \\
 Z_{sc} &= \frac{V_{sc}}{I_{sc}} = \frac{103}{1.13} = 91.15 \Omega \\
 \therefore R_1 + R_2' &= 91.15 \times 0.8678 = 79.1 \\
 R_2' &= 79.1 - 34.25 = 44.85 \Omega \\
 X_1 + X_2' &= 91.15 \times 0.4902 = 44.9 \Omega
 \end{aligned}$$

9.5.3



9.5.4

Hz	Ns
5	150
10	300
15	450
20	600
25	750
30	900
35	1050
40	1200
45	1350
50	1500

9.5.5

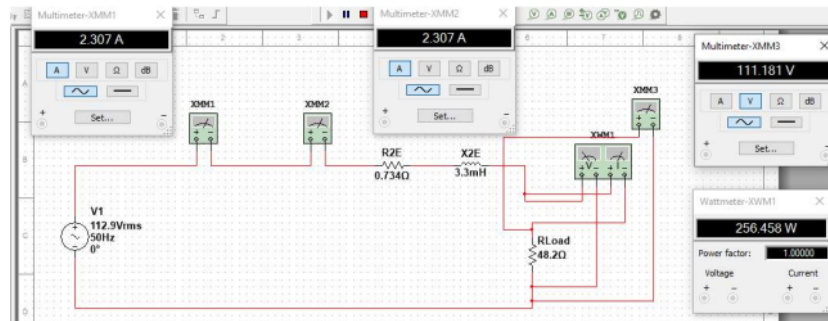
Hz	NR	Vline
5	102.5	111
10	256	117
15	418.5	121
20	568	125
25	721.1	129
30	871.1	133
35	1018	137
40	1171	140
45	1322	144
50	1473	150

9.5.6

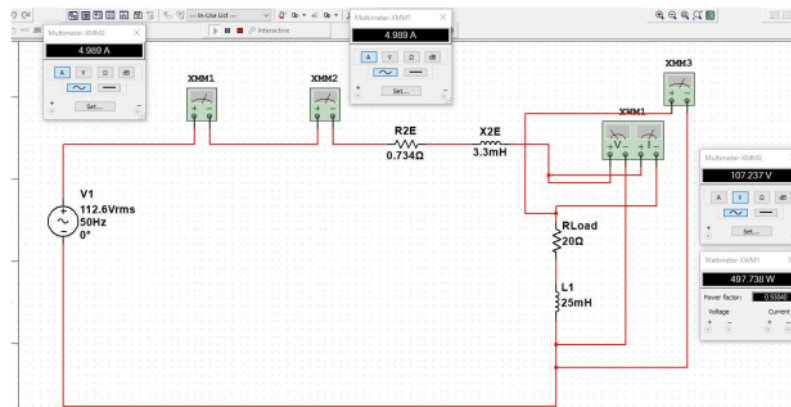
Hz	Ns	NR	S
5	150	102.5	0.32
10	300	256	0.15
15	450	418.5	0.07
20	600	568	0.05
25	750	721.1	0.039
30	900	871.1	0.032
35	1050	1018	0.031
40	1200	1171	0.024
45	1350	1322	0.021
50	1500	1473	0.018

9.6

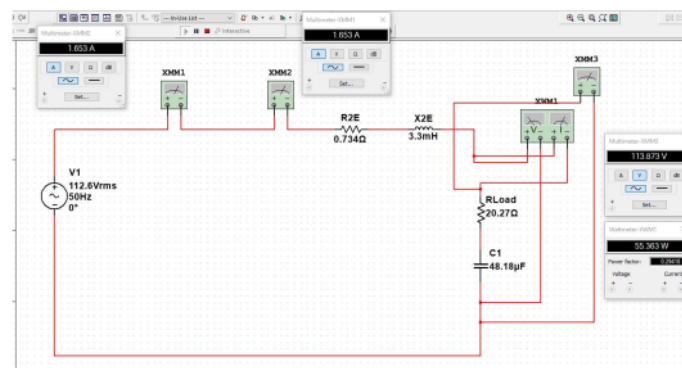
Test 1 (R) Simulated



Test 2 (RL) Sim



Test 3 (RC)



FINAL GRADE

GENERAL COMMENTS

Instructor

63/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

Text Comment. what about your research?

Text Comment. your order is incorrect

Text Comment. repetition

Text Comment. a good summary but contains repetition and says nothing about your research

PAGE 6

Text Comment. brief asked you to fully justify your text

Text Comment. this is supposed to be a plan written in the future tense

Text Comment. this reads like a conclusion not a plan

PAGE 7

Text Comment. phase voltage not phase angle

Text Comment. not quite correct

Text Comment. the angle is the firing angle of the thyristors

Text Comment. phase angle between voltage and current is not the same as the delay angle alpha for the thyristor

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. surname only in citation

Text Comment. good

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 8

QM

Correctly cited

Text Comment. why 18?

QM

Correctly cited

QM

Punctuation Error

Punctuation error

QM

Punctuation Error

Punctuation error

Text Comment. surname?

PAGE 9

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. ???

PAGE 10

Text Comment. power analyser

Text Comment. 2:1

Text Comment. what were your values of R_c and X_m ?

PAGE 11

Text Comment. what were your values of R_{1E} and X_{1E} ?

PAGE 12

Text Comment. the load should be should as this diagram shows a short circuited secondary

Text Comment. what do these results prove?

PAGE 13

Text Comment. what do the results mean?

PAGE 14

PAGE 15

Text Comment. non standard symbol of inductors

Text Comment. good annotations

PAGE 16

Text Comment. power factor increases with torque

Text Comment. what was the relationship between V and f ?

PAGE 17

Text Comment. ???

PAGE 18

Text Comment. brief asks for fully justified text format

PAGE 19

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PAGE 30

PAGE 31

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PAGE 33

GRADING FORM: NEW CSG-RUBRIC

HARRI JONES

63

1. ENGAGEMENT WITH LITERATURE



A good research section with evidence of reading from a wide range of sources cited and listed correctly using the Harvard method. 14/20

14

2. KNOWLEDGE AND UNDERSTANDING



Good knowledge and understanding demonstrated in your research findings, transformer and motor investigation explanations. 12/20

12

3. COGNITIVE AND INTELLECTUAL



Good analysis of transformer and motor investigation results analysis and conclusions/recommendations. However, there were missed opportunities to explain what the results meant in relation to theory and your explanations sometime showed that you did not understand the value of what you have found. 11/20

11

4. PRACTICAL APPLICATION



Good use of equipment for transformer and motor experiments and presentation of results 14/20

14

5. TRANSFERABLE SKILLS



A satisfactory executive summary and work plan, a good risk assessment and explanation of team working. Report is well structured, written and

12

mostyl well presented. Word count not exceeded.
However, there are many poorly presented figures.
12/20