basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

ELECTRICAL TECHNOLOGY (POWER SYSTEMS)

GUIDELINES FOR PRACTICAL ASSESSMENT TASKS

GRADE 12

2020

These guidelines consist of 37 pages.

TABLE OF CONTENT

1. INTRODUCTION

The 17 Curriculum and Assessment Policy Statements subjects which contain a practical component all include a practical assessment task (PAT). These subjects are:

- AGRICULTURE: Agricultural Management Practices, Agricultural Technology
- ARTS: Dance Studies, Design, Dramatic Arts, Music, Visual Arts
- SCIENCES: Computer Applications Technology, Information Technology, Technical Sciences
- SERVICES: Consumer Studies, Hospitality Studies, Tourism
- TECHNOLOGY: Civil Technology, Electrical Technology, Mechanical Technology and Engineering Graphics and Design

A practical assessment task (PAT) mark is a compulsory component of the final promotion mark for all candidates offering subjects that have a practical component and counts 25% (100 marks) of the end-of-the-year examination mark. The PAT is implemented across the first three terms of the school year. This is broken down into different phases or a series of smaller activities that make up the PAT. The PAT allows for learners to be assessed on a regular basis during the school year and it also allows for the assessment of skills that cannot be assessed in a written format, e.g. test or examination. It is therefore important that schools ensure that all learners complete the practical assessment tasks within the stipulated period to ensure that learners are resulted at the end of the school year. The planning and execution of the PAT differs from subject to subject.

Practical assessment tasks are designed to develop and demonstrate a learner's ability to integrate a variety of skills in order to solve a problem. The PAT also makes use of a technological process to inform the learner what steps needs to be followed to derive a solution for the problem.

The PAT consists of four or more simulations and a practical project. The teacher may choose any one of the practical projects and any four simulations available for power systems.

The teacher must apply assessment on an ongoing basis at the same time that the learner is developing the required skills. Four simulations should be completed by the learners, in addition to the manufacturing of a practical project.

The PAT incorporates all the skills the learner has developed throughout the year. The PAT ensures that all the different skills will be acquired by learners on completion of practical work, as well as the correct use of tools and instruments.

Requirements for Presentation

A learner must present the following:

- PAT file with all the evidence of simulations, design and prototyping. A copy of the PAT 2020 cover page. The relevant simulations and assessment sheets should be copied and handed to each learner to include in the file.
- Practical project with:
  - Enclosure:
    - The file must include a design.
    - The enclosure and the design must match.
    - No cardboard boxes are allowed.
    - Plastic and metal enclosures are acceptable.
    - The enclosure should be accessible for scrutiny inside.
    - Lids that are secured with screws are preferred.

- Circuit board:
  - The file should include the PCB design.
  - The PCB must be mounted inside the enclosure in such a manner that it can be removed for scrutiny.
  - Switches, potentiometers, connectors and other items must be mounted.
  - Wiring must be neat and bound/wrapped.
  - Wiring must be long enough to allow for the PCB to be removed and inspected with ease.
- Logo and name:
  - The file should contain the logo and name design.
  - Logo and name must be prominent on the enclosure.

The PAT will have a financial impact on the school's budget and school management teams are required to make provision to accommodate this particular expense.

PAT components and other items must be acquired timeously, for use by the learners, before the end of the first term at the start of the academic year.

It is the responsibility of the HOD to ensure that the teacher is progressing with the PAT from the start of the school year.

Provincial departments are responsible for setting up moderation timetables and consequently PATs should be completed in time for moderation.

2. TEACHER GUIDELINES

2.1 How to Administer PATs

Teachers must ensure that learners complete the simulations required for each term. The project should be started in January in order to ensure its completion by August. In instances where formal assessments take place, the teacher has to assume the responsibility thereof.

The PAT should be completed during the first three terms and must be ready at the start of PAT moderation. Teachers must make copies of the relevant simulations and hand it to learners at the beginning of each term.

The PAT must not be allowed to leave the workshop and must be kept in a safe place at all times when learners are not working on it.

The weightings of the PAT must be adhered to and teachers are not allowed to change weightings for the different sections.

2.2 How to Mark/Assess the PATs

The PAT for Grade 12 will be set and assessed internally, but moderated externally. All formal assessment will be done by the teacher.

The teacher is required to produce a **working model and model answer file** that sets the baseline for assessment at a Highly Competent Level for every project choice exercised by the learners. This file must include all the simulations with answers the teacher has done him/herself. The teacher will use the model answers and project to assess the simulations and projects of the learners.

Once a facet sheet has been completed by the teacher, assessment will be deemed to be complete. **No re-assessment will be done once the facet sheets have been completed** and captured by the teacher. Learners must ensure that the work is done to the required standard before the teacher finally assesses the PAT during each stage of completion.

2.3 PAT Assessment Management Plan

The assessment plan for the PAT is as follows:

TIME FRAME	ACTIVITY	RESPONSIBILITY
	Preparation for PAT 2020	Teacher – Builds the models and works out the model answers for the simulations for 2020. Identifies shortages in tools, equipment and consumable items for simulations that must be procured in 2020 SMT – Receives procurement requests from teachers and processes payments for the acquisition of required items
January–March 2020	Simulations 1 and 2	Teacher – Copies and hands out simulations Learners – Complete simulations Teacher – Assesses simulations HOD – Checks if tasks have been completed and marked by the teacher before the holiday
January 2020	PAT project – procurement	Teacher – Obtains quotations for PAT projects Principal – Approves PAT procurement for PAT projects Teacher – Ensures that PAT projects are ordered and delivered HOD – Checks in on teacher to see if the process is adhered to
February 2020	PAT project – learners commence with project	Teacher – Ensures that there is secure storage for PAT projects Teacher – Hands out and takes in PAT projects Teacher – Includes practical sessions for learners to complete the PAT project every week Learners – Commence with completion of the PAT project HOD – Checks in on teacher to ensure that practical workshop sessions take place on a weekly basis
April–June 2020	Moderation of Simulations 1 and 2	District subject facilitator/subject specialist will visit the school and moderate Simulation 1 and 2 10% of learners' work is moderated
April–June 2020	Simulations 3 and 4	Teacher – Copies and hands out simulations Learners – Complete simulations Teacher – Assesses simulations HOD – Checks if tasks have been completed and marked by the teacher before the holiday
April–June 2020	PAT project – learners continue with project	Teacher – Ensures that there is secure storage for PAT projects Teacher – Hands out and takes in PAT projects Teacher – Includes practical sessions for learners to complete the PAT project every week Learners – Continue with completion of the PAT project HOD – Checks in on teacher to ensure that practical workshop sessions take place on a weekly basis
July holidays 2020	PAT intervention	Learners that are behind on the PAT are required to complete the project during this holiday.
July–August 2020	Moderation of Simulations 3 and 4	District subject facilitator/subject specialist will visit the school and moderate Simulations 3 and 4 – different learners from the previous term 10% of learners' work is moderated
July–August 2020	PAT project – completion	Teacher – Ensures that there is secure storage for PAT projects Teacher – Hands out and takes in PAT projects Teacher – Completes the PAT project with learners and compiles the PAT file Learners – Completes the PAT project and file HOD – Checks to see that 100% of the PAT files and projects are completed and assessed
September–October 2020	PAT moderation	PAT projects are moderated by subject facilitators/subject specialists from the province and learners are available to demonstrate skills 10% of learners are moderated randomly

2.4 Moderation of PATs

Provincial moderation of each term's simulations will start as early as the following term. Simulations 1 and 2 should be moderated as soon as the second term starts. Similarly, Simulations 3 and 4 will be moderated in July. The project will, however, only be moderated on completion.

During moderation of the PAT the learner's file and project must be presented to the moderator.

The moderation process is as follows:

- During moderation, learners are randomly selected to demonstrate the different simulations. All four simulations will be moderated.
- **The teacher is required to build an exemplar model for each project type chosen for the school.**
- **This model must be on display during moderation.**
- **The teacher's model forms the standard of the moderation at Level 4 (Highly Competent).**
- **Level 5 assessments must exceed the model of the teacher in skill and finishing.**
- Learners who are moderated will have access to their files during moderation and may refer to the simulations they completed earlier in the year.
- Learners may NOT ask assistance from other learners during moderation.
- All projects and files must be on display for the moderator.
- **If a learner is unable to repeat the simulation or cannot produce a working circuit during moderation, marks will be deducted and circuits assessed as not being operational.**
- The moderator will randomly select no fewer than **two projects** (not simulations) and the learners involved will have to explain how the project was manufactured.
- Where required, the moderator should be able to call on the learner to explain the function and principles of operation, and request the learner to exhibit the skills acquired through the simulations for moderation purposes.
- On completion the moderator will, if needed, adjust the marks of the group upwards or downwards, depending on the outcome of moderation.
- Normal examination protocols for appeals will be adhered to, if a dispute arises from adjustments made.

2.5 Absence/Non-submission of Tasks

The absence of a PAT mark in Electrical Technology without a valid reason: The learner will be given three weeks before the commencement of the final end-of-year examination to submit outstanding task. Should the learner fail to fulfil the outstanding PAT requirement, such a learner will be awarded a zero (0) for that PAT component.

2.6 Simulations

Simulations are circuits, experiments and tests/tasks which the learner will have to build, test and measure and practically do as part of the development of practical skills. These skills have to be illustrated to the external moderator that visits the school at intervals during the school year.

Teachers who make use of simulation programs on a computer may use it for the learners to practice on. However, it is required that the circuit be built using real components and that measurements be made with actual instruments for the purposes of assessment and moderation.

The correct procedure for completing simulations is outlined below for teachers and school management teams who are responsible for the implementation of the PAT in Electrical Technology.

STEP 1: The teacher will choose simulations from the provided examples.
STEP 2: Compile a list of the components needed for every simulation. Add extra components as these items are very small and you will need extras, as these items get lost/damaged very easily when learners are working with it.
STEP 3: Contact three different electronics component suppliers for comparative quotations.
STEP 4: Submit the quotations to the SMT for approval and procurement of the items.
STEP 5: Place the components in storage. Collate items for each simulation, thus making it easier to distribute and use during practical sessions. Ensure that different values of components do not mix, as this would lead to components being used incorrectly and this could damage the component and in extreme cases, the equipment used.
STEP 6: Copy the relevant simulations and hand them out to learners at the start of the term.

Teachers are allowed to adjust circuits and component values to suit their environment/ resource availability.

Teachers are required to develop a set of model answers in the teacher's file.

Moderators will use the teacher's model answers and artefacts when moderating.

2.7 Projects

The projects are construction projects teachers can choose for their learners. These projects are based on proven circuits provided from schools and subject advisors. The projects are based on working prototypes and require careful construction in order for it to operate correctly.

Projects are varied in cost and teachers must ensure that the projects chosen fall within the scope of the school's budget.

Once the teacher has decided on a circuit, he/she must construct the prototype. Thereafter, copies of the provided circuit can be made and distributed to learners. They MUST redraw these circuits in their file correctly.

The description of the operation of the circuits is NOT complete. It is required of learners to interrogate the function of the components in the provided circuit. They should elaborate on the purpose of components in the circuit. It is recommended that those learners investigate similar circuits available on the internet and in the school library or workshop reference books.

2.8 Working Mark sheet
(A working Excel file is provided with this PAT)

PAT Mark Sheet		Term 1		Term 2		Project		Total = Term1 + Term 2 + Project 250	Mark out of 100	Moderated Mark
No.	Name of Learner	Simulation 1 40	Simulation 2 40	Simulation 3 40	Simulation 4 40	Design and Make Part 1 70	Design and Make Part 2 20			
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
	Total									
	Average									

Teacher Name: ____________________ Principal Name: ____________________ Moderator Name: __________________

Signature: _________________________ Signature: _________________________ Signature: _________________________

Date: ____________________________ Date:___________________________ Date:_____________________

School Stamp

3. LEARNER GUIDELINES

PAT 2020 cover page (Place this page at the front of the PAT.)

Department of Basic Education
Grade 12
CAPS for Technical High Schools
Practical Assessment Task – Electrical Technology

Time allowed: Terms 1–3 (2020)

Learner Name: ____________________________________

Class: ____________________________________

School: ____________________________________

Specialisation: POWER SYSTEMS

Complete FOUR simulations.

Project (Write the name of the project): ______________________________

Evidence of moderation:

NOTE:
When the learner evidence (LE) selected has been moderated at school level, the table will contain evidence of moderation. Provincial moderators will sign the provincial moderation and only sign if re-moderation is needed.

Moderation	Signature	Date	Signature	Date
School-based				
Provincial moderation			Re-moderation	

Mark allocation

PAT Component	Maximum Mark	Learner Mark	Moderated Mark
Simulation 1	40		
Simulation 2	40		
Simulation 3	40		
Simulation 4	40		
Design and Make Project – Circuit	70		
Design and Make Project – Enclosure	20		
Total	**250**		

3.1 Instructions to learner

- The practical assessment task counts 25% of your final promotion mark.
- All work produced by you must be your own effort. Group work and co-operative work are not allowed.
- The practical assessment task must be completed over three quarters.
- The PAT file must contain 4 simulations and a practical project.
- Calculations should be clear and include units. Calculations should be rounded off to TWO digits. SI units should be used.
- Circuit diagrams can be hand-drawn or drawn on CAD. No photocopies or scanned files are allowed.
- Photos are allowed and can be in colour or greyscale. Scanned photos and photocopies are allowed.
- This document must be placed inside your PAT file together with the other evidence.
- Learners with identical photos will be penalised and receive zero for that section

3.2 Declaration of Authenticity (COMPULSORY)

Declaration: I ________________________ herewith declare that the work represented in this evidence is entirely my own effort. I understand that if proven otherwise, my final results may be withheld.

___________________________________ ____________
Signature of learner Date

4. SIMULATIONS

4.1 Simulation 1: RLC circuit

Name of learner: ______________________________	**Mark**	___________ 40
Class: ___________ **Date Completed:** _____________		
Date Assessed: _______________	Assessor Signature: _________________	
Date Moderated: ______________	Moderator Signature: ______________________	

4.1.1 PURPOSE

- To build an RLC series circuit.
- To measure the total current of a series RLC circuit over a wide range of frequencies.
- To display the voltage waveforms across different components and observe the relationships between the voltages.

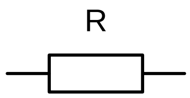
4.1.2 COMPONENT LIST

- Any audio transformer (interstage impedance matching transformer found in modems, audio circuits – value is not critical)
- 0,1 μF capacitor (104)
- 1kΩ (brown black red 5% - ¼ watt)
- Function generator (disconnect the earth terminal of the function generator)
- Experiment board
- Connecting wires
- 4 x multimeters
- Oscilloscope with two probes (disconnect the earth terminal of the oscilloscope)

4.1.3 RLC SERIES CIRCUIT

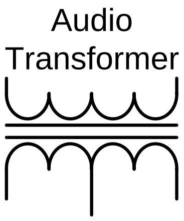
(a) Measure the exact value of following components before connecting the circuit.

Exact resistance of R (will differ slightly from learner to learner): (2)



R = _____________ (1)

The exact resistance of L (the resistance of the coil being used)



R_L = _____________

(1)

(b) Build the circuit diagram in FIGURE 4.1 on your experiment board. You will be assessed with the rubric below.

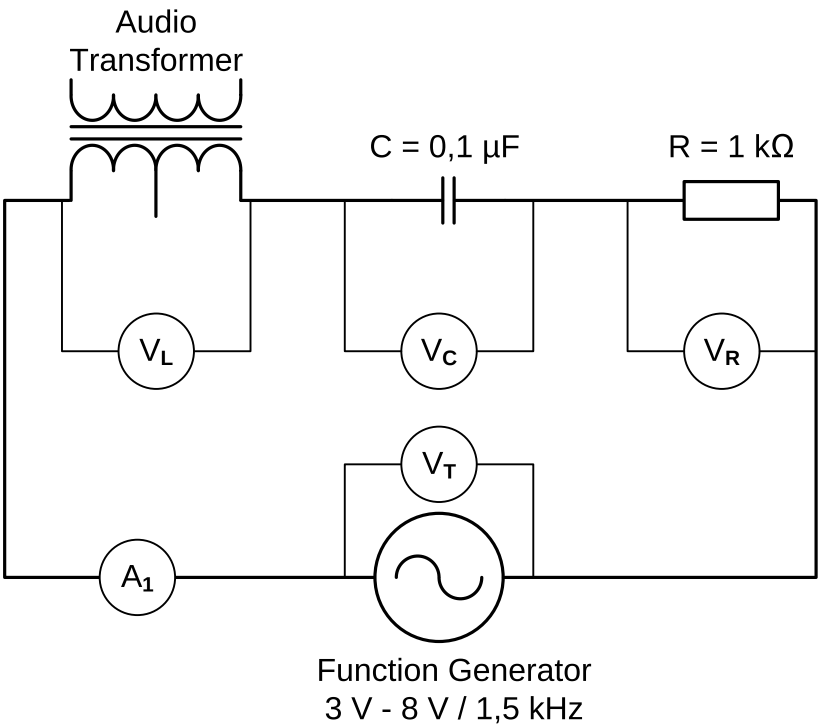


FIGURE 4.1

Level descriptor				**Marks obtained**
0	**1**	**2**	**4**	
The candidate was not able to construct the circuit on his own.	The candidate was able to partially construct the circuit on his own.	The candidate was able to correctly construct the circuit with the assistance of the teacher.	The candidate constructed the circuit correct without the assistance of the teacher	
The candidate was not able to connect the measuring instruments	The cadidate was able to partially connect the measuring instruments to the circuit	The candidate connected the measuring instruments correctly and measured the voltages and currents after the assistance of the teacher	The candidate connected the measuring instruments correctly and measured the voltages and currents on his own	

(8)

4.1.4 **PROCEDURE**

(a) Set the function generator to a sine wave and adjust the voltage to between 3–8 V sine wave. (Set the voltage as high as the function generator allows)
NOTE: Once the voltage is set do not change the amplitude of the voltage.

Set the frequency. (Teachers are requested to change the frequency for each learner, Use frequency intervals in such a manner that each learner has a unique frequency. (Teachers should choose frequencies where the required reaction (Reactance) from the circuit is evident. This is dependent on the value of the coil, which is determined by the components chosen.)

Write down the frequency assigned to you

f = ____________

NOTE: Do not adjust the frequency unless instructed to do so.

(b) Connect the multimeters to reflect the following: (5)

V_L = ______________________________

V_C = ______________________________

V_R = ______________________________

V_T = ______________________________

I_T = ______________________________

(Meters must be true RMS meters set to AC to ensure correct readings)

(c) Calculate the total current in the circuit using V_R and the measured value of R.

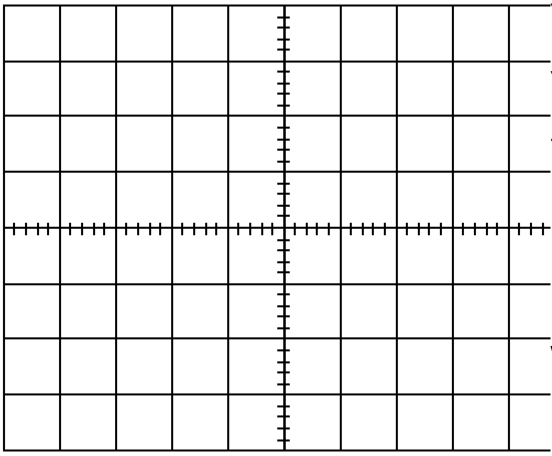
$V_R = I_T \times R$ ______________________________

____

____

(2)

(d) Draw the two waveforms displayed on the oscilloscope screen to illustrate the phase relationship between VR and VL. (NOTE: Schools that have digital scopes can make screenshots and print the screenshot – Learners may not copy from each other)



V/Div:___________ (Ch 1)

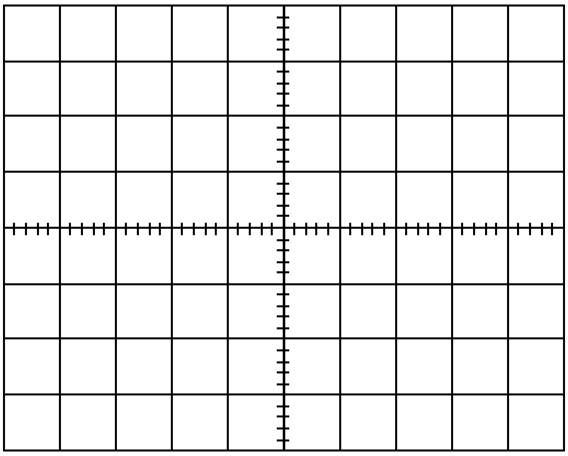
V/Div:___________ (Ch 2)

T/Div: ___________

NOTE:
1 mark for each correctly drawn waveform.
1 mark for the oscilloscope settings.

(3)

(e) Draw the two waveforms displayed on the oscilloscope screen to illustrate the phase relationship between VR and VC.



V/Div:___________ (Ch 1)

V/Div:___________ (Ch 2)

T/Div: ___________

NOTE:
1 mark for each correctly drawn waveform.
1 mark for the oscilloscope settings. (3)

(f) Calculate the impedance of the circuit (Z)

(3)

(g) Calculate XC by using the specific frequency assigned to you in 4.1.3.

(3)

(h) Calculate the total reactance X using R and R_L:
RL = resistance of the inductor you measured in 4.1.1(b).

$$X = \sqrt{Z^2 - (R + R_L)^2}$$

____
____
____
____ (2)

(i) Calculate the inductive reactance (XL) from X and XC.

$$X_L = X - X_C$$

____
____
____
____ (2)

(j) Calculate the inductance of the coil (L) from XL.

____
____
____
____ (3)

(k) Tabulate your values in the following table and compare it with the given results:

Candidate's results

V COIL	VC	VT	VR	IT	R	Z	X	XL	XC	L

Typical values

V COIL	VC	VT	VR	IT	R	Z	X	XL	XC	L
6,6 V	4,5 V	7,9 V	3,1 V	3,1 mA	1 000 Ω	2 548 Ω	---	740 Ω	1 592 Ω	117 mH

(l) State whether the frequency of the supply must increase or decrease for the circuit to resonate. Motivate your answer

____
____
____
____ (2)

(m) Explain how the voltages in a RLC series circuit can be leading and lagging.
Why is reference made to the phase shift of the voltages and not current in this instance?

____
____ (2)

CONCLUSION

In a series AC circuit, the current is equal in all components.
The voltage in the inductor leads the supply voltage and the voltage in the capacitor lags the supply voltage.

TOTAL: 40

4.2 Simulation 2: Inspecting and testing the three-phase AC electrical motor

Name of learner: ______________________________	**Mark:**	______ 40
Class: ___________ **Date completed:** _____________		
Date assessed: ______________	**Assessor signature:** ______________________	
Date moderated: ______________	**Moderator signature:** ______________________	

4.2.1 **PURPOSE**

To conduct the following:

- Visual mechanical inspections
- Electrical inspection/test of the motor using measuring instruments

4.2.2 **REQUIRED RESOURCES**

TOOLS/INSTRUMENTS	CONSUMABLES
• Three-phase AC motor • Multimeter • Insulation tester (megger)	

4.2.3 **PROCEDURE**

Use the list below to conduct an inspection test on a three-phase AC electrical motor.
Complete the results in the table below.

ACTIVITY 2A:

Complete the details on the nameplate of the motor that is being tested, (the information must be written as it appears on the nameplate of the motor, i.e. write the values of the voltage and the current as they appear on the nameplate.

Phase:____________________________ Voltage: ________________

Pole pairs:__________________________ Speed:_________________

Efficiency:__________________________ Current: ________________

Power rating:_______________________ Frequency: ______________ (8)

ACTIVITY 2B: Complete the table below.

NOTE: These testing procedures are conducted when the motor is electrically isolated from the supply.

DESCRIPTION	VISUAL/ELECTRICAL INSPECTION/TESTING AND READINGS TAKEN	MARKS ALLOCATED
Condition of windings: Measurements taken		
Test 1: Continuity of the windings (Write the reading shown on the multimeter in ohms.) (3 marks)		
A1–A2		
B1–B2		
C1–C2		
Test 2: Insulation resistance between windings (Write the reading shown on the insulation resistance tester in Megger-ohms.) (3 marks)		
A1–B1		
A1–C1		
B1–C1		
Test 3: Insulation resistance to Earth (Write the reading shown on the insulation resistance tester) (3 marks)		
A1–Earth		
B1–Earth		
C1–Earth		
Test 4: Mechanical inspection Note all errors (3 marks) (Brief description)		
Rotor is free to rotate		
Motor interior is free from dust, water and oil		
Play in bearings		
Condition of motor frame (Brief description) (6 marks)		
Condition of termination box		
Flange/Foot mount		
Front/Back-end shield		
Stator/Field housing		
Mounting bolts and nuts/screws		
Condition of cooling fan, fan cover and cooling fins		

(18)

For conventional phase sequence labelling of the terminal of the motor. (3)

Correct internal wiring of the motor tested (2)

According to the regulation, state the minimum acceptable resistance between the windings when insulation resistance test is conducted. (1)

4.2.4

CONDUCTED TEST	ACCEPTABLE/NOT ACCEPTABLE, MOTIVATE YOUR ANSWER	
Winding resistance		(2)
Insulation resistance		(2)
Earth resistance		(2)
State with a reason whether the motor can be used or not		(2)

[40]

4.3 Simulation 3: STAR-DELTA starter with overload and timer

Name of learner: ________________________	**Mark:**	____ 40
Class: __________ **Date completed:** ____________		
Date assessed: ____________	**Assessor signature:** __________________	
Date moderated: ____________	**Moderator signature:** __________________	

4.3.1 **PURPOSE**

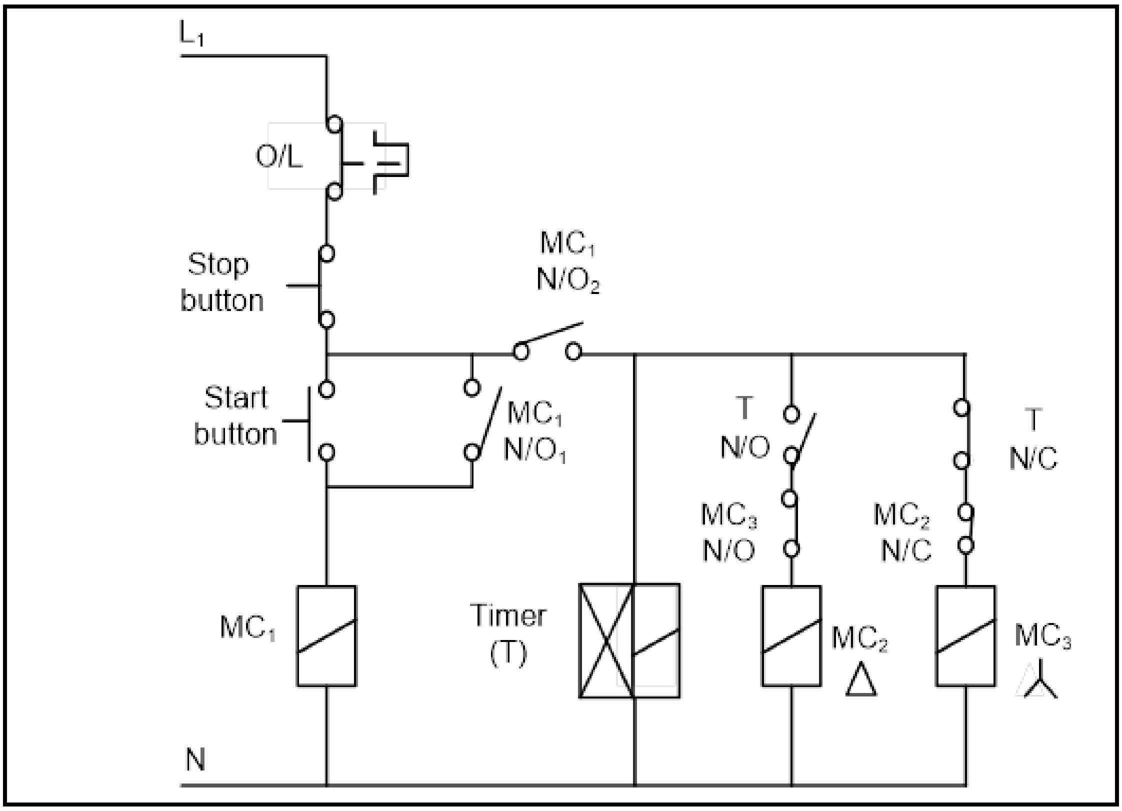
To reduce the input voltage to the **motor** so as to reduce the starting current.

4.3.2 **REQUIRED RESOURCES**

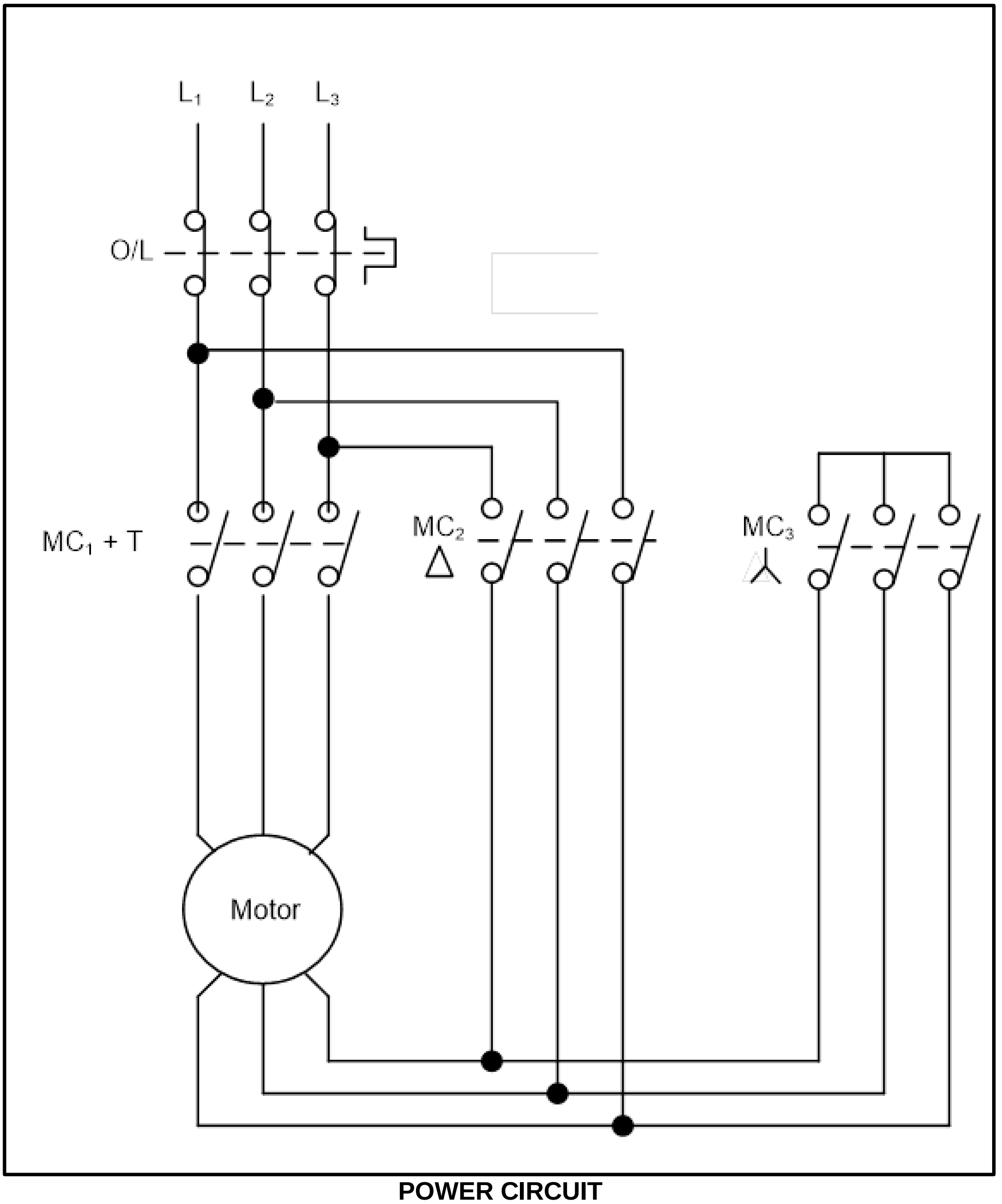
TOOLS/INSTRUMENTS	CONSUMABLES
• 2 x three-phase contactors with auxiliary contacts (for delta and star connection) • 1 x three-phase main contactor with timer • 1 x three-phase overload relay • 1 x stop button • 1 x start button • 1 x three-phase induction motor • Correct wire size or plug-in leads • Wire-stripper • Long nose pliers • Screwdriver • Side cutters	• Multimeter or continuity tester • Clamp-on ammeter

Build the control and the power circuit on the panels and let the teacher check the circuits before switching on.

After the start button is pressed and released, the motor will run in star. When the motor has reached near or rated speed, then it switches into delta or after a pre-set time, the motor will switch into delta.



CONTROL CIRCUIT



POWER CIRCUIT

4.3.3 **PROCEDURE**

Consider all safety aspects before and during the wiring process and be cautious until the motor is operating.

(a) Wire and test the control circuit before connecting it to the power circuit.

Ask your teacher to check the functionality of the control circuit

(b) Wire the power circuit and connect it to the control circuit.

(c) Start the motor and observe.

(d) The teacher will insert faults on the control circuit and the learner must identify them.

4.3.4 **ACTIVITY 3**

(a) Measure the voltage between: (Use a voltmeter and set it to the highest scale)

L1 and L2 = ________V (1)

L_1 and L_3 = ________V (1)

L_2 and L_3 = ________V (1)

Any of the line
and neutral = ________V (1)

(b) Measure the current when the motor is running in: (Use a clamp on meter)

Star = ________A (1)

Delta = ________A (1)

State your observation when the motor is running in star and in delta

(4)
[10]

FACET: Simulation 3: THE STAR-DELTA STARTER

FACETS	FACET 1	FACET 2	FACET 3	FACET 4	MAXIMUM POSSIBLE MARKS	LEARNER'S MARK
Preparation of the Simulation	Correctly interpreting the wiring diagram of control and power circuit	Correctly identifying and collecting all devices	Correctly identifying and collecting all measuring instruments	Correctly Identifying and collecting all tools	**8 marks max.** For each facet (2 marks if correct) (1 mark if partially completed)	
Wiring of Control Circuit	Testing the functionality of all devices to be used	Correct procedure in wiring the circuit	Operation of the circuit		**6 marks max.** For each facet (2 marks if correct) (1 mark if partially completed)	
Correct Connection of Measuring Instruments	Correct procedure in connecting the instruments	Testing the insulation between conductors	Testing continuity in the circuit		**6 marks max** For each facet (2 marks if correct) (1 mark if partially completed)	
Wiring of Power Circuit	Testing the functionality of the motor	Correct procedure in wiring the circuit			**4 marks max.** For each facet (2 marks if correct) (1 mark if partially completed)	
Setting of Fault				Fault successfully identified	2	
Safety				Safety precautions were observed	2	
Housekeeping				Housekeeping was practised	2	
				Activity	**(10)**	
				Facets Marks	**(30)**	
				TOTAL	**[40]**	

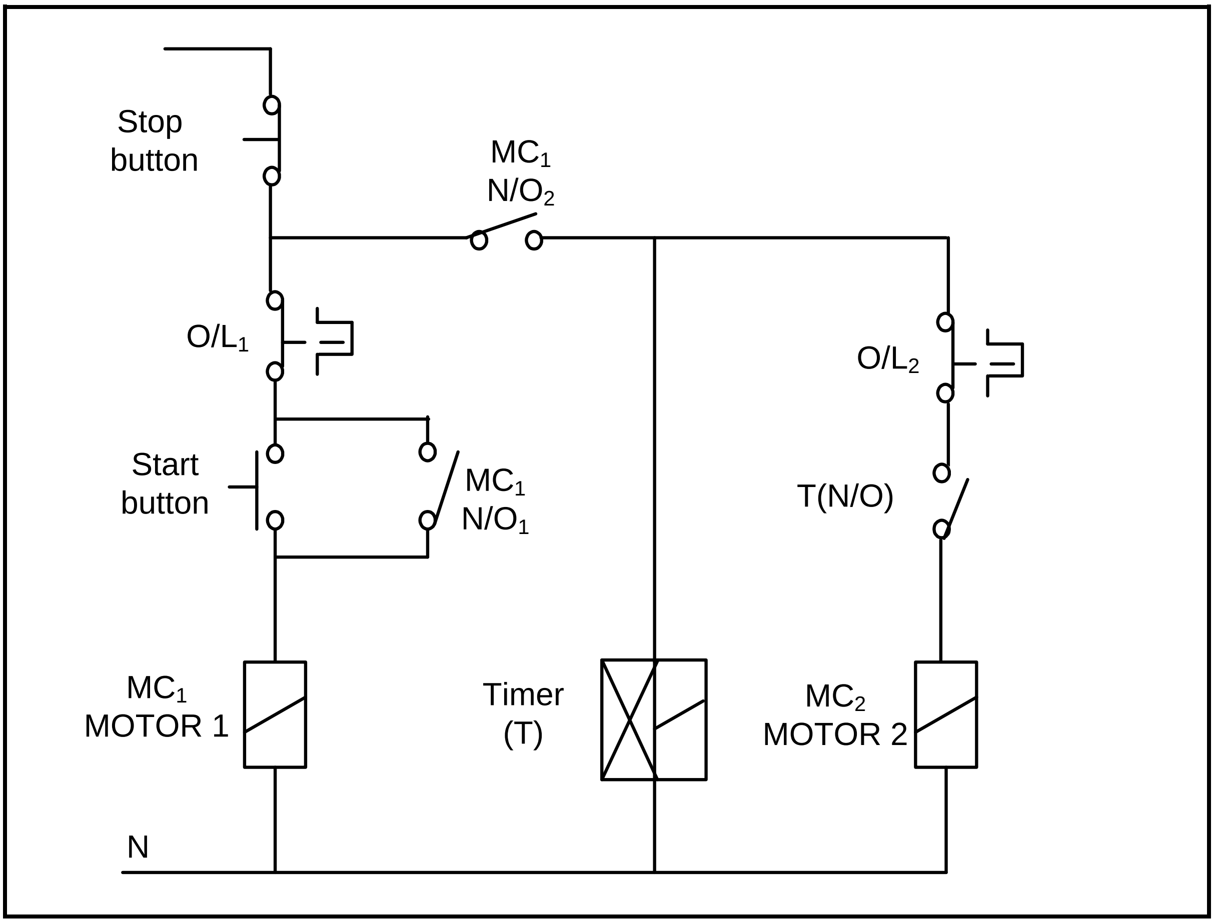
4.4 Simulation 4: Three-phase sequence motor control starter with overload and timer using PLC

Name of learner: ______________________	**Mark:**	______ / 40
Class: __________ **Date completed:** __________		
Date assessed: __________	**Assessor signature:** __________	
Date moderated: __________	**Moderator signature:** __________	

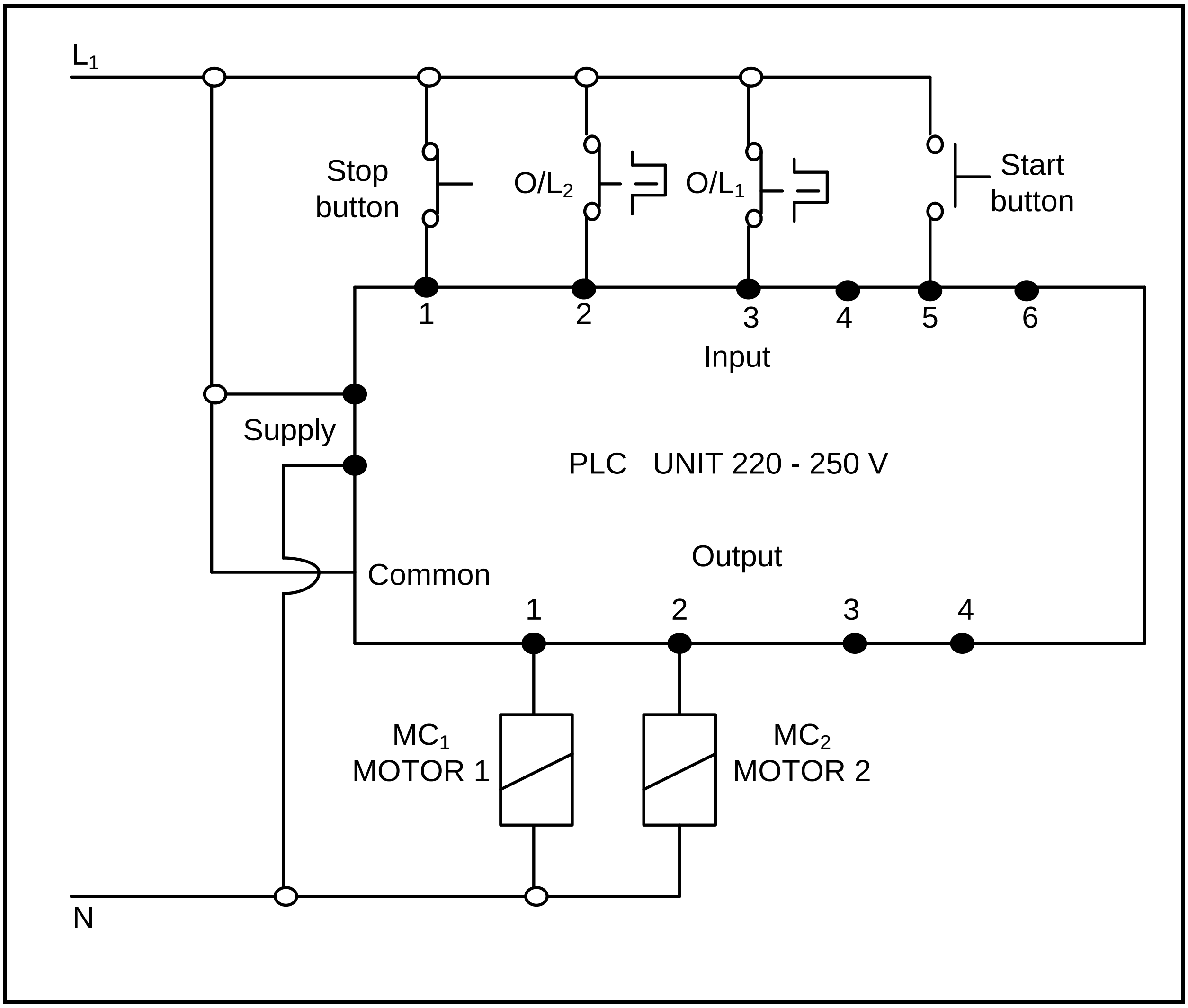
4.4.1 **PURPOSE**

Practical simulation of a three-phase sequence motor control starter with overload and timer using PLC

Control circuit

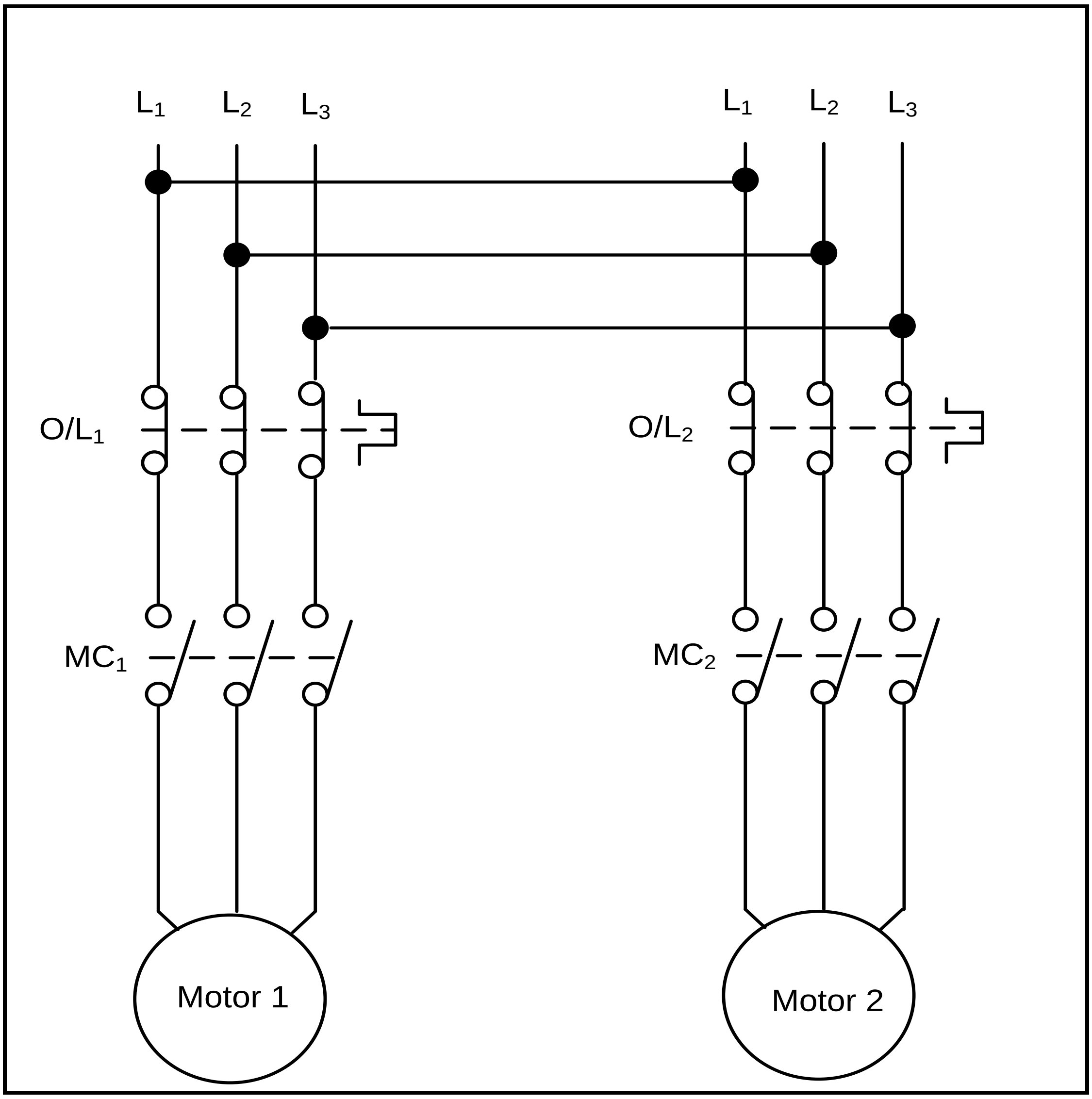


CONTROL CIRCUIT



PLC UNIT CONNECTED TO THE CONTROL CIRCUIT

X1/I01 = Stop button
X2/I02 = O/L $_2$
X3/I03 = O/L $_1$
X5/I05 = Start button



POWER CIRCUIT

4.4.2 **RESOURCES REQUIRED**

TOOLS/INSTRUMENTS	MATERIALS
• Multimeter/Clamp meter or continuity tester • Computer/Programmer • Wire-stripper • Long-nose pliers • Screwdriver • Side cutters	• Connecting wires • PLC unit • 2 x three-phase induction motors • 2 x three-phase overload relays • 1 x stop button • 1 x start button • 2 x three-phase contactors with auxiliary contacts

4.4.3 **PROCEDURE**

- Program the ladder logic diagram through a computer and load the program to the PLC.
- Run the PLC program and simulate the operation.
- Connect the PLC to control the circuit
- Do not switch on the supply before the teacher has checked the circuit.
- When the circuits are correct, switch the supply on.
- Run the PLC program to start the motor.
- The teacher will insert faults on the PLC and the learner must identify them

The operation:

When the start button is pressed, Motor 1 will run. After pre-set time, Motor 2 also run. Both motors must be able to be stopped by a stop button.

The teacher should create faults on the PLC program for the learners to identify.

4.4.1 **ACTIVITY 4:**

(a) Take a snapshot (screenshot) of the programmed ladder logic diagram. Save print and paste it on the blank space below.

(4)

(b) Explain why Motor 1 and Motor 2 cannot run simultaneously after the start button is pressed and released. (2)

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____

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[6]

FACET: Simulation 4: Three-phase sequence motor control starter with overload and timer using PLC

FACETS	FACET 1	FACET 2	FACET 3	FACET 4	MAXIMUM POSSIBLE MARKS	LEARNER'S MARK
Preparation of the Simulation	Correctly interpreting the wiring diagram of control and power circuit	Correctly identifying and collecting all devices	Correctly identifying and collecting all measuring instruments	Correctly identifying and collecting all tools	**8 marks max.** For each facet (2 marks if correct) (1 mark if partially completed)	
Wiring of Control Circuit	Testing the functionality of all devices to be used	Correct procedure in wiring the circuit	Testing continuity in the circuit	Operation of the circuit	**8 marks max.** For each facet (2 marks if correct) (1 mark if partially completed)	
PLC Unit	Develop the ladder logic diagram in the computer correctly	Correctly loading the program from the computer to the PLC unit	Correctly connecting the PLC unit to control the circuit	Run the program to start the motor.	**8 marks max.** For each facet (2 marks if correct) (1 mark if partially completed)	
Wiring of Power Circuit	Testing the functionality of the motor	Correct procedure in wiring the circuit	Testing continuity in the circuit		**6 marks max.** For each facet (2 marks if correct) (1 mark if partially completed)	
Safety				Safety precautions were observed	**2 marks max.** For each facet (2 marks if correct) (1 mark if partially completed)	
Housekeeping				Housekeeping was practiced	**2 marks max.** For each facet (2 marks if correct) (1 mark if partially completed)	
				Activity 4	**(6)**	
				Facet	**(34)**	
				TOTAL	**[40]**	

5. SECTION B – DESIGN AND MAKE

Design and Make Project

Time: January to August 2020

Learner Name: ______________________________

School: ______________________________

Class: ______________________________

Title/Type of Project: ______________________________

INSTRUCTIONS

- This section is COMPULSORY for all learners.
- The teacher will choose a circuit for the project.
- Any project constructed must include at least (but is not limited to):
  - Seven components
  - A variety of components (both active and passive)
  - PCB making in some form
  - Soldering
  - An enclosure with a switch and protection
- The checklist below must be used to ensure that all the required tasks for the PAT have been completed.

PAT CHECKLIST

The learner MUST complete this checklist for the teacher BEFORE marking of the section takes place!

NO.	DESCRIPTION	TICK (☑)	
		NO	YES
Design and Make: Part 1			
1.	Circuit diagram drawn	☐	☐
2.	Circuit description filled in	☐	☐
3.	Component list completed	☐	☐
4.	Tools list for circuitry populated	☐	☐
5.	Measuring instrument list filled in	☐	☐
6.	Evidence of prototyping printed and pasted into the file	☐	☐
7.	Learner's own Vero board/PCB planning/design printed and included in file	☐	☐
Design and Make: Part 2			
1.	Enclosure design completed and included in the file	☐	☐
2.	Unique name written down and on the enclosure	☐	☐
3.	Logo designed and on the enclosure	☐	☐
Miscellaneous			
1.	Enclosure included in the project	☐	☐
2.	Enclosure prepared and drilled according to the design	☐	☐
3.	Enclosure finished off and completed with name and logo	☐	☐
4.	PCB securely mounted in the enclosure using acceptable techniques	☐	☐
5.	Circuit inside the enclosure accessible	☐	☐
6.	Internal wiring neat and ready for inspection	☐	☐
7.	File and project completed and ready for moderation at the workshop/room	☐	☐

5.1 Design and make: Part 1

5.1.1 Circuit diagram

Draw a circuit diagram of your project and add it after this page.

5.1.2 Project: Description of operation

Use the space below to provide an overview of how the project functions. Use your own words and do some research of your own.

5.1.3 **Component list**

Draw up a list of components you will need from the circuit diagram.

LABEL	DESCRIPTION AND VALUE	QUANTITY

5.1.4 **Tools/Instrument list**

Draw up a list of tools you will need to complete the PAT circuitry. You may add to the list as you proceed through the PAT.

DESCRIPTION	PURPOSE/USE

5.1.5 **Evidence of prototyping**

Take photographs of the working prototype on the breadboard using a digital camera or cellphone and insert here. Add your name on the photograph.

5.1.6 **PCB design**

Design a printed circuit board layout for the circuit you are going to build.

Print it out and attach after this page.

5.2 **Assessment of the Design and Make Phase: Part 1**

NO.	FACET DESCRIPTION	Mark	Achieved = 1 Not achieved = ×
	Circuit Diagram		
1.	The circuit diagram was drawn using EGD equipment.	1	
2.	The circuit diagram was drawn using CAD/any electronic design software.	1	
3.	The circuit diagram was drawn using correct symbols.	1	
4.	The circuit diagram has all labels – R1, C1, Tr1, etc.	1	
5.	The circuit diagram has all component values –100 Ω, 220 μF, etc.	1	
6.	The circuit diagram has a name / title.	1	
7.	The circuit diagram has a frame and title block. (EGD approach).	1	
	Component List		
8.	Labels correlate with circuit diagram.	1	
9.	Description and values correlate with circuit diagram.	1	
10.	Quantities are correct.	1	
	Description of Operation		
11.	Basic function of the circuit is described correctly.	1	
12.	All sub circuits in the circuit diagram and component list are included in the description.	1	
13.	Purposes of sub circuits in the circuit diagram are described correctly.	1	
14.	Learner used own interpretation and did not copy from another source verbatim.	1	
15.	Sources are acknowledged.	1	
	Tools/Instrument List		
16.	The tools/instrument list has been completed.	1	
17.	The tools/instruments listed all have a purpose for being used.	1	
	Evidence of Prototyping on Breadboard		
18.	Unique, original photos of the prototyping are included.	1	
19.	Unique, original photos include the learner name.	1	
20.	Photos are clear and in focus: All components are clearly identifiable.	1	
21.	Prototype is operational. No photo, no mark.	2	
	PCB Design		
22.	Printed Circuit Board design is included in the PAT file.	1	
23.	PCB Design is made using a CAD approach.	3	
24.	Component overlay showing placement is included.	1	
25.	Components are labelled the same as in the circuit diagram.	1	
26.	The design is original and does not match any other learner's design.	1	
27.	Board layout (tracks/current flow) is functional and matches the original circuit diagram.	1	
	Circuit Board Manufacturing		
28.	Circuit board is etched neatly according to the PCB design.	5	
29.	The learner’s name is etched onto the circuit design.	1	
30.	The PCB is tinned neatly.	1	
31.	The soldered PCB, solder side, is covered with a clear protective coating (Plastic 70/clear lacquer).	1	

NO.	FACET DESCRIPTION	Mark	Achieved = 1 Not achieved = ✗
32.	Holes are drilled neatly and are aligned in the middle of the pads on the PCB.	1	
33.	Mounting holes of the PCB are drilled symmetrically.	1	
34.	All burrs are removed.	1	
35.	The PCB is cut neatly/squarely and edges are filed neatly.	1	
36.	Axial and radial components are placed neatly and flush with the board.	1	
37.	Component orientation are aligned between similar components (e.g. the gold band of all resistors are placed on the same side).	1	
38.	Soldered components – leads are cut off, flush and neat on the solder side.	2	
39.	More than 60% of the solder joints are shiny (not dry joints).	2	
40.	Wire insulation is stripped to the correct length (no extra copper showing).	2	
41.	Wiring is long enough to allow for dismantling and inspection.	1	
42.	Wiring is wrapped neatly.	1	
43.	A power switch is included and fitted to the enclosure.	2	
44.	A fuse/protection is included and fitted correctly where applicable.	2	
45.	Wiring entering/exiting the enclosure is provided with a grommet/applicable fittings/sockets where applicable.	2	
46.	Batteries are mounted using a battery housing/mounting bracket and battery clip (NO double-sided tape).	1	
47.	The project has a pilot light/LED installed in the enclosure showing when the circuit is operational. (Switch is on – must go out when fuse is blown.)	1	
48.	The project is fully operational and commissioned/installed in the enclosure.	10	

TOTAL (PART 1 = 70 marks)	

NOTE: In projects where facets not applicable, the projects should be marked, and the totals adjusted accordingly.

5.3 **Design and Make: Part 2**

(a) **Enclosure design**

- Design an enclosure for your project.
- NO FREEHAND DRAWINGS.
- Draw using EGD equipment **OR** use a CAD program.
- Draw in first-angle orthographic projection.
- Add your drawings after this page.
- Use colour to enhance your drawing.

(b) Manufacture the enclosure neatly according to your design.
You may use pre-cut panels from metal, wood and or perspex/plexiglass. You must however construct/assemble these parts.
Injection moulded enclosures are also acceptable. It is important that your enclosure and the placement of the parts align with your design.

(c) Choose a name for your device.
Write down the name of the device below.

____

(d) Design a unique logo for your device, as well as a specification plate and attach it after this page.

[20]

5.4 Assessment of the Design and Make Phase: Part 2

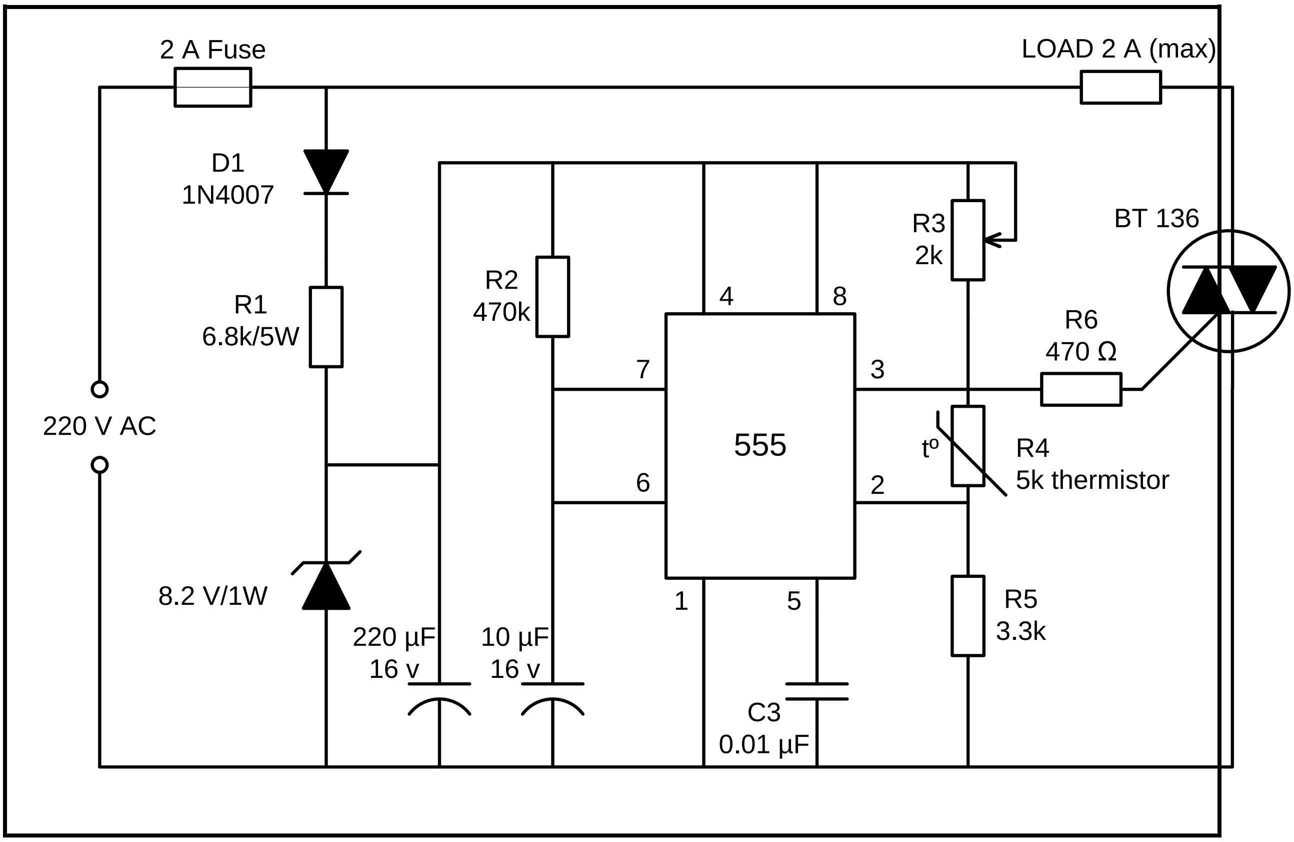
NO.	FACET DESCRIPTION	Mark	Achieved = 1 Not achieved = ✘
	Enclosure Design		
1.	Enclosure design is included in first-angle orthographic projection.	1	
2.	Drawn design includes a title box and page border.	1	
3.	Isometric drawing included additionally.	1	
4.	Dimensions are included.	1	
5.	The name of the device is written in the PAT document.	1	
6.	The logo design and specification plate design is in the PAT document.	2	
	Subtotal (7 marks max.)		
	Enclosure Manufacturing		
7.	Enclosure matches the design. – Dimensions and placement correlate.	1	
8.	Name of the device is attached on the enclosure.	1	
9.	The logo design is attached on the enclosure.	1	
10.	The logo design on the enclosure is durable and not merely a paper pasted on the enclosure (painted/used decoupage/screen printed/sublimation printed).	1	
11.	The enclosure is manufactured from scratch / pre-cut parts. **Does NOT include:** cardboard, paper, margarine container **Does include:** sheet metal, Perspex, Plexiglas, wood, glass and other raw materials, injection-moulded plastic boxes	3	
12.	Holes/Cut-outs in the enclosure are made with the appropriate tools.	2	
13.	Specification plate with the learner's name, operating voltage, fuse rating and additional information on the project.	1	
14.	Enclosure is neatly prepped, painted and aesthetically pleasing.	2	
15.	The circuit board is mounted using appropriate methods inside the enclosure. (NO double-sided tape, Prestik, glue, chewing gum, masking tape, etc.)	1	
	Subtotal (13 marks max.)		

TOTAL (PART 2 = 20 marks)	

6. PROJECTS

6.1 Practical Project 1: SOLDERING IRON HEAT CONTROL CIRCUIT

Soldering iron temperature controller circuit with the 555 IC together with a thermistor resister divider, to control the temperature of a soldering iron. The dividing network consists of adjustable resistor R3 thermistor R4 and R5. It is especially useful if the soldering iron is to be kept on for long since you can control the dissipation from the iron. When a soldering iron is switched on, it takes time to reach melting point. Simply connect this circuit to the soldering iron as shown below and the iron reaches the solder's melting point quickly. Maximum current it could deliver is 2 A.



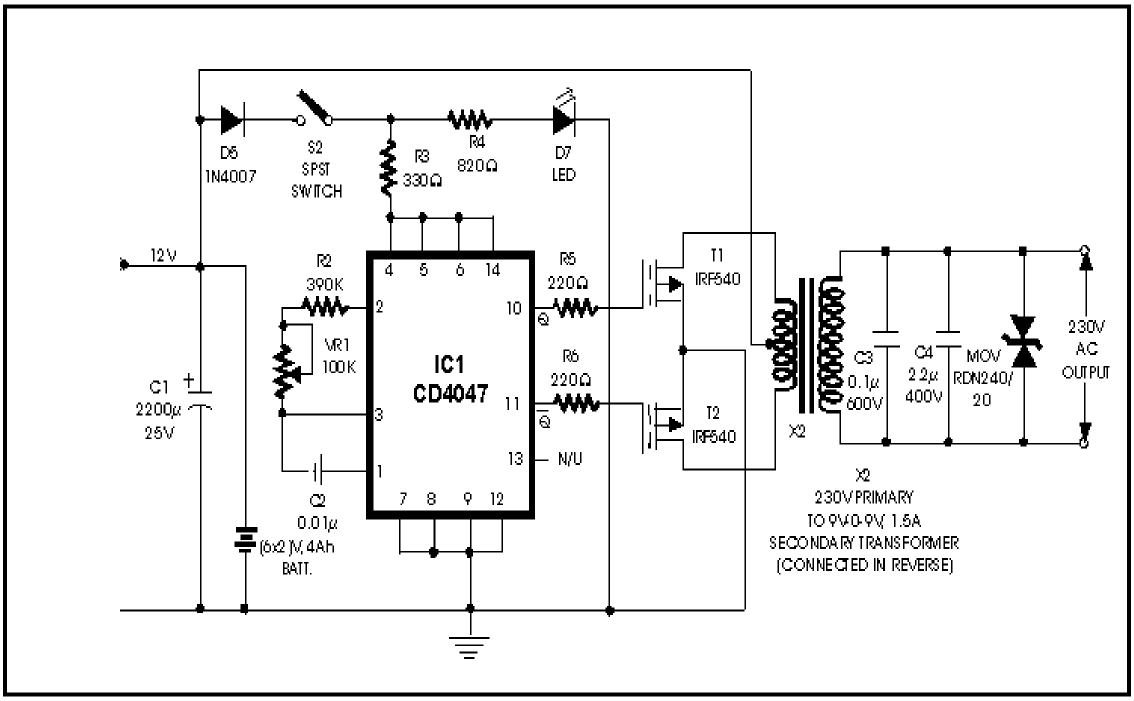
SOLDERING IRON HEAT CONTROL CIRCUIT

COMPONENT LIST	
RESISTORS	**CAPACITORS**
R1 6.8 k/5 W	C1 220 µF/16 V (Polarised capacitor)
R2 470 k Ω	C2 10 µF / 16 V (Polarised capacitor)
R3 2 kΩ (Adjustable resistor)	C3 0.01 µF/16 V (Non-polarised capacitor)
R4 5k Ω (Thermistor)	**DIODES**
R5 3.3 kΩ	TRIAC BT136
R6 470 Ω	D1 1N4007
IC 555 timer	Zener diode 8,2/1V

6.2 Practical Project 2: Inverter 100 W 12 VDC to 230 VAC by IC 4047 – IRF540

100 W inverter circuit 12 VDC to 230 VAC with IRF540. The circuit applied IC 4047 to generate continuous wave signal and IRF540 to amplify the signal to be stepped up by the transformer.

NOTE: You will need a 2–3 A centre tapped transformer to handle/supply 100 W load.



Inverter 100 W 12 VDC to 230 VAC by IC 4047 – IRF540

COMPONENT LIST

Diode	1N4007	VR1	100 KΩ
C1	2 200 µF	R2	390 KΩ
C2	0,01 µF	R3	330 Ω
C 3	0,1 µF	R4	820 Ω
C 4	2,2 µF	R5	220 Ω–330 Ω
		R6	220 Ω–330 Ω
IC 4047 – IRF540		2 x D MOSFET (T1) IRF540	
LED		S2 SPST switch	
Supply 12 V or 12 V DC supply for testing			
TRANSFORMER on circuit diagram optional a smaller one can be used for testing.			

NOTE: All circuits MUST include an On/Off Switch with a ON indicator and fuse protection.

7. CONCLUSION

On completion of the practical assessment task learners should be able to demonstrate their understanding of the industry, enhance their knowledge, skills, values and reasoning abilities as well as establish connections to life outside the classroom and address real-world challenges. The PAT furthermore develops learners' life skills and provides opportunities for learners to engage in their own learning.