basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

ELECTRICAL TECHNOLOGY (POWER SYSTEMS)

GUIDELINES FOR PRACTICAL ASSESSMENT TASKS (PAT)

GRADE 12

2022

These PAT guidelines consist of 40 pages.

TABLE OF CONTENTS

1. INTRODUCTION

The 18 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; Technical Mathematics
- 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 simulations and a practical project. The teacher may choose any ONE of the practical projects and any TWO 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. TWO 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 2022 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, wooden and metal enclosures are acceptable.
    - Enclosures that are manufactured and/or assembled by the learners are preferred.
    - The enclosure should be accessible for scrutiny inside.
    - Lids that are secured 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. Alternatively, inspection can be made from the bottom in cases where translucent (see-through) enclosures are used.
  - 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 and specification plate.
  - Logo, specification plate and name must be prominent on the enclosure.
  - The logo/specification plate must be affixed in a permanent manner – painted, glued or stuck on with vinyl

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 responsibility therefore.

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 them 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 them.

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 Programme of Assessment (PAT PoA)

The programme of assessment (PoA) for the PAT is as follows:

TIME FRAME	ACTIVITY	RESPONSIBILITY
	Preparation for PAT 2022	Teacher – Builds the models and works out the model answers for the simulations for 2022. Identifies shortages in tools, equipment and consumable items for simulations that must be procured in 2022. SMT – Receives procurement requests from teachers and processes payments for the acquisition of required items
January–March 2022	Simulation 1	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 2022	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 2022	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 2022	Simulation 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
April–June 2022	Moderation of Simulation 1	District subject facilitator/subject specialist will visit the school and moderate simulation 1 10% of learners' work is moderated
April–June 2022	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 2022	PAT intervention	Learners that are behind on the PAT are required to complete the project during this holiday.
July–August 2022	Moderation of Simulation 2	District subject facilitator/subject specialist will visit the school and moderate simulation 2 – different learners from the previous term 10% of learners' work is moderated
July–August 2022	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 – Complete the PAT project and file HOD – Checks to see that 100% of the PAT files and projects are completed and assessed
September–October 2022	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. Simulation 1 should be moderated as soon as the second term starts. Similarly, Simulation 2 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. Both simulations will be moderated.
- **The teacher is required to build a model of each project 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 use simulation programs on a computer may use them 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 are lost/damaged very easily when learners work with them.
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 them to operate correctly.

Projects vary 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 portfolios correctly.

The description of the operation of the circuits is NOT complete. Learners are required 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 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 = Term 1 + Term 2 + Project 250	Mark out of 100	Moderated Mark
No.	Name of Learner	Simulation 1 50	Simulation 2 50	Design and Make Part 1 120	Design and Make Part 2 30			
	Total							
	Average							

Teacher Name: _______________ Principal Name: _______________ Moderator Name: _____________

Signature: ___________________ Signature: ___________________ Signature: ___________________

Date: _______________________ Date:________________________ Date:___________________

3. LEARNER GUIDELINES

PAT 2022 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 (2022)

Learner Name: ____________________________________

Class: ____________________________________

School: ____________________________________

Specialisation: POWER SYSTEMS

Complete TWO 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				
District moderation				
Provincial moderation			Re-moderation	

Mark allocation

PAT Component	Maximum Mark	Learner Mark	Moderated Mark
Simulation 1	50		
Simulation 2	50		
Design and Make Project – Circuit	120		
Design and Make Project – Enclosure	30		
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 is NOT allowed.
- The practical assessment task must be completed over three terms.
- The PAT file must contain TWO simulations and a practical project.
- Calculations should be clear and include units. Calculations should be rounded off to TWO decimals. 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 may be in colour or greyscale. Scanned photos and photocopies are allowed.
- Learners with identical photos will be penalised and receive zero for that section.
- This document must be placed inside your PAT file together with the other evidence.

3.2 Declaration of Authenticity (COMPULSORY)

Declaration:

I ______________________________ (Name) herewith declare that the work represented in this File/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 series circuit

Name of learner: ________________________________

Mark ____ / 50

Class: ____________ **Date Completed:** ________________

Date Assessed: ________________ **Assessor Signature:** ______________

Date Moderated: _______________ **Moderator Signature:** ______________

4.1.1 Purpose:

- To understand the operation of a resistor, inductor and capacitor in a series circuit with an AC supply.
- To understand resonant frequency.
- To compare the measured and the calculated values.

4.1.2 Procedure:

Build the series RLC circuit in FIGURE 4.1.4 on the breadboard using the components provided.
Connect the circuit to a function generator.
Set the output signal voltage of the function generator to 5 V with a frequency of 50 kHz.
Take the measurements as asked in TABLE 4.1.5 with the frequency adjusted to 50 Hz, 159 Hz and 500 Hz and then answer the questions that follow.

4.1.3 Required resources:

COMPONENTS	TOOLS AND EQUIPMENT
R_1 = 100 Ω resistor L_1 = 10 µH inductor C_1 = 100 µF capacitor	Multimeter Function generator Leads Breadboard Side cutters Pair of pliers Oscilloscope

4.1.4 **Circuit Diagram:**

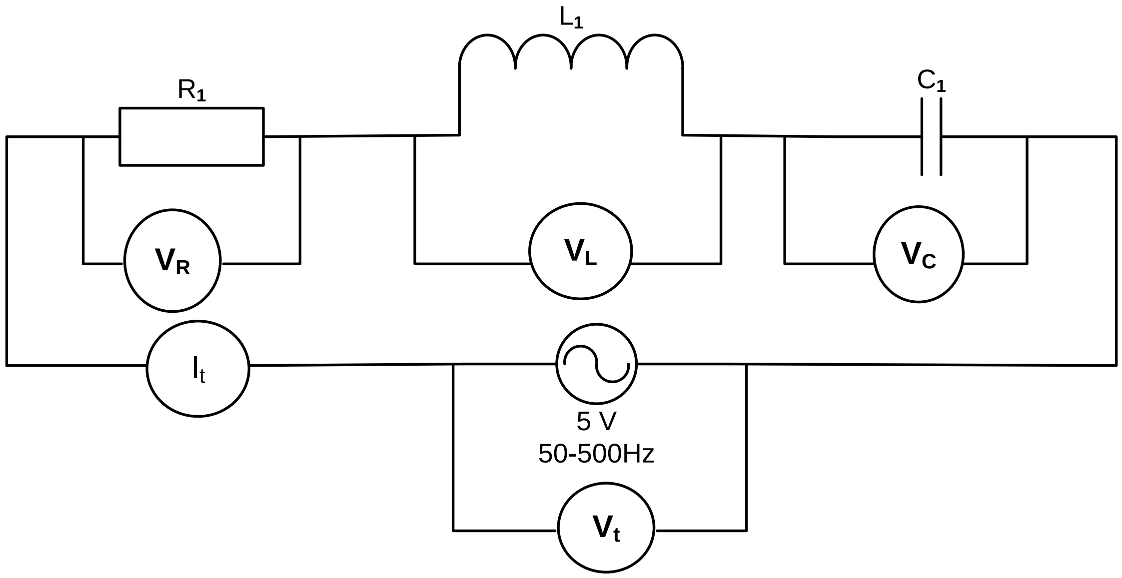


FIGURE 4.1.4: RLC CIRCUIT DIAGRAM

4.1.5 Complete TABLE 4.1.5 by entering measured values of V_R, V_L, V_C, V_T and I_T.
NOTE: Alternatively measure with the oscilloscope and convert to V_{rms} values.

METERS CONNECTED ACROSS	MEASUREMENTS AT 50 Hz	MEASUREMENTS AT 159 Hz	MEASUREMENTS AT 500 Hz
V_R			
V_L			
V_C			
V_T			
I_T			

TABLE 4.1.5 (13)

4.1.6 Study the measurements in TABLE 4.1.5 above and answer the following:

(a) Compare the values of V_L and V_C at 50 Hz. (2)

____

____

(b) Calculate the values of X_L and X_C at 50 Hz with: (4)

$X_L = 2\pi f L$

$X_C = \frac{1}{2\pi f C}$

X_L = ______________________

X_C = ______________________

(c) Compare the values of V_L and V_C at 500 Hz. (2)

(d) Calculate the values of X_L and X_C at 500 Hz. (4)

X_L = X_C =

(e) Compare the values of V_L and V_C at 159 Hz. (2)

(f) Calculate the values of X_L and X_C at 159 Hz. (4)

X_L = X_C =

(g) Calculate the resonant frequency. (3)

4.1.7 Write a conclusion about the measurements in 4.1.5 and calculations in 4.1.6 when the circuit is at resonance. (4)

RUBRIC FOR SIMULATION 1

LEVEL DESCRIPTOR				**MARKS OBTAINED**
0	**1**	**2**	**4**	
The learner was not able to build the circuit on his own.	The learner was able to partially build the circuit on his own.	The learner was able to correctly build the circuit with the assistance of the teacher.	The learner built the circuit correctly without the assistance of the teacher.	
The learner was not able to connect the measuring instruments.	The learner was able to partially connect the measuring instruments to the circuit.	The learner connected the measuring instruments correctly and measured the voltages and currents with the assistance of the teacher.	The learner connected the measuring instruments correctly and measured the voltages and currents on his own.	

(12)

Total: [50]

4.2 Simulation 2: Three-phase transformer

Name of learner: ______________________________	**Mark**	________ 50
Class: __________ **Date Completed:** ____________		
Date Assessed: ______________	**Assessor Signature:** ____________________	
Date Moderated: ______________	**Moderator Signature:** ____________________	

4.2.1 **Purpose:**

- To connect three identical single-phase step-down transformers in star-delta to a three-phase supply.
- To connect the secondary to a load that consists of three identical incandescent lamps that are connected in delta.
- To measure the primary and secondary line and phase voltages and currents.

4.2.2 **Required resources:**

TOOLS/INSTRUMENTS/DEVICE	CONSUMABLES
Three identical step-down single-phase transformers Three-phase supply Clamp meter and multimeter Wire stripper Long-nose pliers Screw driver Side cutters Isolation tester (Megger)	Connecting wires Three identical incandescent lamps

4.2.3 **Procedure:**

Connect the primary windings of each transformer to the supply and the secondary to the load (lamp).
Complete TABLE 4.2.3 by measuring the primary and secondary voltages of each single-phase transformer before connecting them in star-delta configuration.
NOTE: Use single phase to connect (live and neutral).

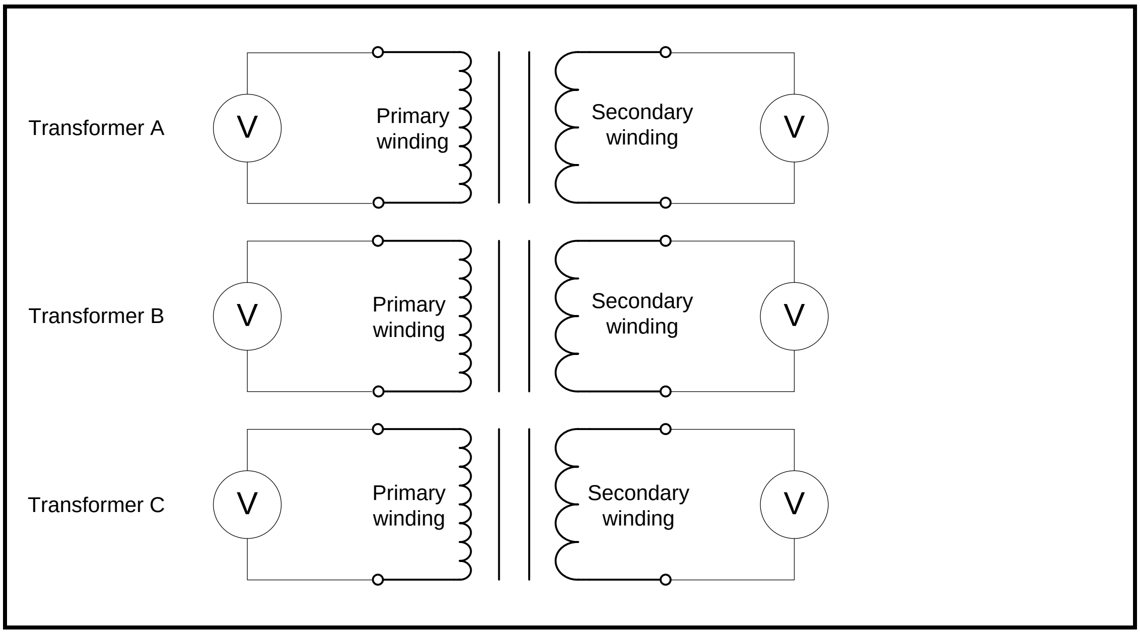


FIGURE 4.2.3: THREE SINGLE-PHASE TRANSFORMERS

TRANSFORMER	PRIMARY VOLTAGE	SECONDARY VOLTAGE
A	$V_{Prim(A)}$ =	$V_{SEC(A)}$ =
B	$V_{Prim(B)}$ =	$V_{SEC(B)}$ =
C	$V_{Prim(C)}$ =	$V_{SEC(C)}$ =

TABLE 4.2.3 (6)

4.2.4 Calculate the transformer ratio of each single-phase transformer using the voltage values from TABLE 4.2.3. It only has to be done once. The transformers are identical.

TRANSFORMER A	TRANSFORMER B	TRANSFORMER C
TR =	TR =	TR =

(3 x 3) (9)

4.2.5 Explain whether these transformers are fit to be used as a star-delta connected three-phase unit.
NOTE: Your answer must be informed by transformer ratio calculations.
(2)

____

____

____

4.2.6 Draw the circuit diagram in which these transformers are connected in a star-delta configuration using colour coding and correct labelling. Show the connection of the load.

STAR-DELTA CONFIGURATION TRANSFORMER

NOTE: 3 marks for primary connection (3 x line and 1 neutral)
3 marks for secondary connection (3 x line)
3 marks for load connection (3 x line) (Any 9 marks) (9)

4.2.7 Connect THREE identical single-phase step-down transformers in star-delta to a three-phase supply.
Connect the primary (star) to the three-phase supply and the secondary (delta) to a load that consists of three identical incandescent lamps. The lamps must be connected in delta too.

NOTE:
The secondary voltage of the transformer is not critical. The only requirement is that the secondary voltage and the voltage of the lamps must be compatible.
It is the duty of the teacher to verify that the learners connect the transformers correctly, before connecting the mains supply. If you are not entirely sure of your connections do NOT switch on. Test for short circuits.
Mains supply can be lethal. Be extremely careful.

4.2.8 Measure the primary and secondary line and phase voltages and currents. Record the readings in the table below.

Primary side		
Readings on line voltages, phase voltages and line currents		
V_{L1} & V_{L2} =	V_{L1} & N =	I_{L1} =
V_{L1} & V_{L3} =	V_{L2} & N =	I_{L2} =
V_{L2} & V_{L3} =	V_{L3} & N =	I_{L3} =
Secondary side		
Readings on line voltages, phase voltages and line currents		
V_{L1} & V_{L2} =	I_{PH1} =	I_{L1} =
V_{L1} & V_{L3} =	I_{PH2} =	I_{L2} =
V_{L2} & V_{L3} =	I_{PH3} =	I_{L3} =

(18)

4.2.9 Calculate the primary apparent power. (3)

____

____

____

4.2.10 **CONCLUSION:** Your conclusion must be based on the table above and other observations. (3)

____

____

____

[50]

4.3 Simulation 3: Automatic STAR-DELTA starter with overload

Name of learner: ______________________	**Mark**	______ / 50
Class: __________ **Date Completed:** ____________		
Date Assessed: ____________	**Assessor Signature:** ________________	
Date Moderated: ____________	**Moderator Signature:** ________________	

4.3.1 Purpose:

- To investigate the effect of a star-delta motor with reference to current and voltage at start-up.

4.3.2 Required Resources

TOOLS/INSTRUMENTS	MATERIAL
2 x three-phase contactors with auxiliary contacts (for forward and reverse connection) 1 x three-phase main contactor 1 x three-phase overload relay 1 x stop button 1 x start button 1 x three-phase induction motor Tools Correct wire size or plug-in leads Wire-stripper Long-nose pliers Screwdriver Side cutters	Multimeter or continuity tester Multimeter or voltmeter 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, it switches into delta or after a pre-set time, the motor will switch into delta.

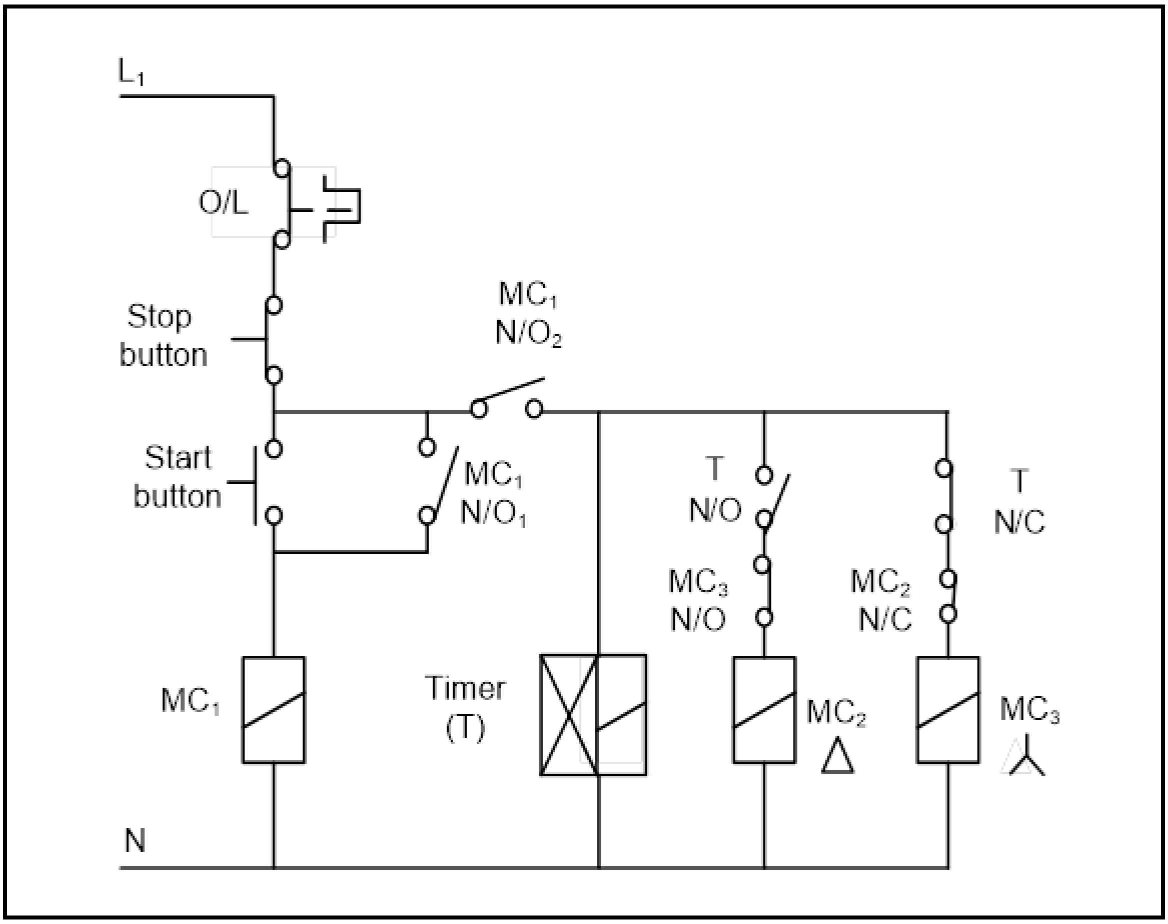


FIGURE 4.3.2(a): AUTOMATIC STAR-DELTA CONTROL CIRCUIT

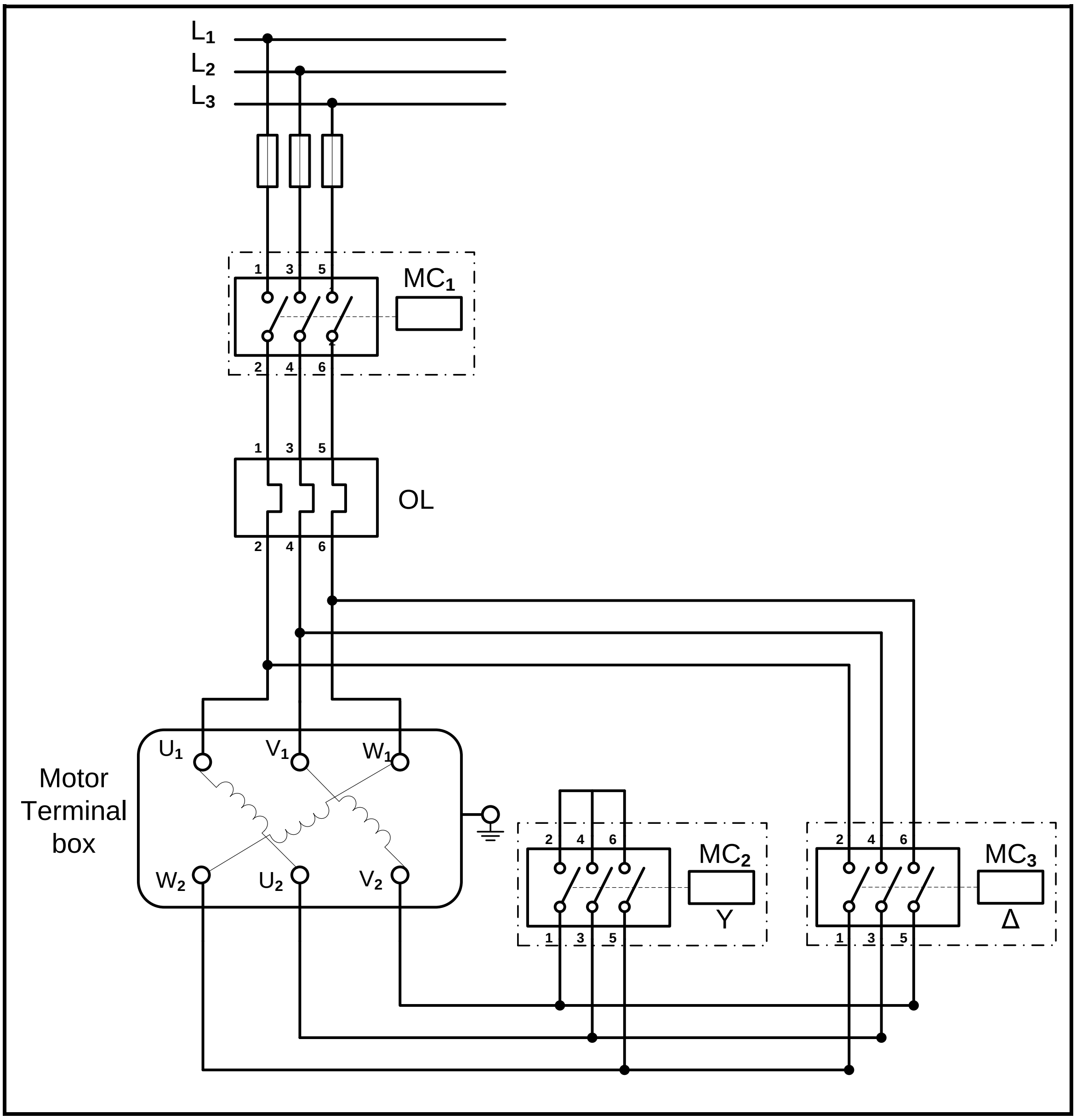


FIGURE 4.3.2(b): AUTOMATIC STAR-DELTA POWER CIRCUIT

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 control circuit before switching on the supply.

(b) Wire the power circuit and connect it to the control circuit.
Ask your teacher to check the power circuit before switching on the supply.

(c) Start the motor and observe.

(d) Use a voltmeter to measure the required voltages in TABLE 4.3.4(a).

(e) Use an ammeter to measure the required currents in TABLE 4.3.4(b).

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

4.3.4 **Activity 3:**

(a) Complete the table below by measuring the phase voltages of the motor when it is running in star and after it switches to delta. (Use a voltmeter and set it to the highest scale.)

PHASE VOLTAGES		
	STAR	**DELTA**
Phase 1		
Phase 2		
Phase 3		

TABLE 4.3.4(a) (6)

(b) Complete the table below by measuring the currents drawn from the supply when the motor is running in star and after it switches to delta. (Use a clamp-on meter.)

LINE CURRENTS		
	STAR	**DELTA**
Line 1		
Line 2		
Line 3		

TABLE 4.3.4(b) (6)

(c) Study the measurements in TABLE 4.3.4(a) and compare the voltages in star to the voltages in delta. (2)

____

(d) Study the measurements in TABLE 4.3.4(b) and compare the currents in star to the currents in delta. (2)

(e) Write a conclusion based on the measurements in TABLES 4.3.4(a) and (b). (4)

[20]

FACET: SIMULATION 3: THE STAR-DELTA STARTER

FACETS	FACET 1	FACET 2	FACET 3	MAXIMUM POSSIBLE MARKS	LEARNER'S MARK
Preparation of the simulation	Testing the functionality of all devices to be used (stop/start buttons, contactors, etc.) **(1)**	Correctly identifying and collecting all contactors and components **(1)**	Correctly identifying and collecting all tools and measuring instruments **(1)**	**3 marks max.**	
Wiring of control circuit	Correct procedure when wiring the circuit **(1)**	Wiring the control circuit: Without assistance **(3)** Being assisted once **(2)** Being assisted more than once **(1)**	Correct colour coding used for wiring the control circuit **(1)**	**5 marks max.**	
Operation of the control circuit	Power circuit works partially **(2)**	Power circuit works correctly **(5)**		**5 marks max.**	
Use of measuring instruments	Correct use of continuity tester **(1)**	Correct use of ammeter **(1)**	Correct use of voltmeter **(1)**	**3 marks max**	
Wiring of power circuit	Correct procedure when wiring the circuit **(1)**	Wiring the power circuit: Without assistance **(3)** Being assisted once **(2)** Being assisted more than once **(1)**	Correct colour coding used for wiring the power circuit **(1)**	**5 marks max.**	
Operation of the power circuit	Power circuit works partially **(2)**	Power circuit works correctly **(5)**		**5 marks max.**	
Setting of fault and fault finding	Fault successfully identified **(1)**	Fault successfully corrected **(1)**	Safety precautions were observed **(1)**	**3 marks max**	
Housekeeping	Housekeeping was practised (1)			**1 mark max**	
			Facet Total:	**(30)**	
			Activity:	**(20)**	
			Facet Marks:	**(30)**	
			TOTAL:	**[50]**	

4.4. Simulation 4: Forward-reverse motor starter with overload using PLC

Name of learner: ______________________________	**Mark**	______ / 50
Class: ___________ **Date Completed:** _____________		
Date Assessed: _____________	**Assessor Signature:** ______________________	
Date Moderated: _____________	**Moderator Signature:** ______________________	

4.4.1 **Purpose:**

- To modernise an old relay panel forward-reverse motor starter and change it to a PLC system.

Scenario:

A company is under new management and decided to update their old relay systems to PLC systems. One system that needs updating is an electric motor that can turn in forward and reverse direction by pushing two different start buttons, one for forward and another for reverse. When the motor is turning in the forward direction, it must be stopped first before starting it in reverse. It must not be able to change direction without pressing the stop button. Overload protection is used to monitor the current to the motor. The overload relay must disconnect the current to the motor the moment it surpasses the rated current.

Control circuit:

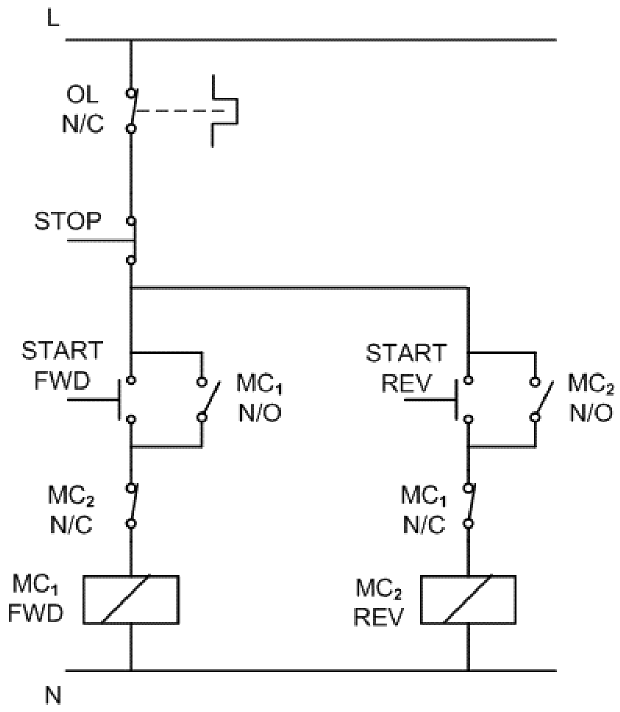


FIGURE 4.4.1(a): RELAY LOGIC CONTROL CIRCUIT

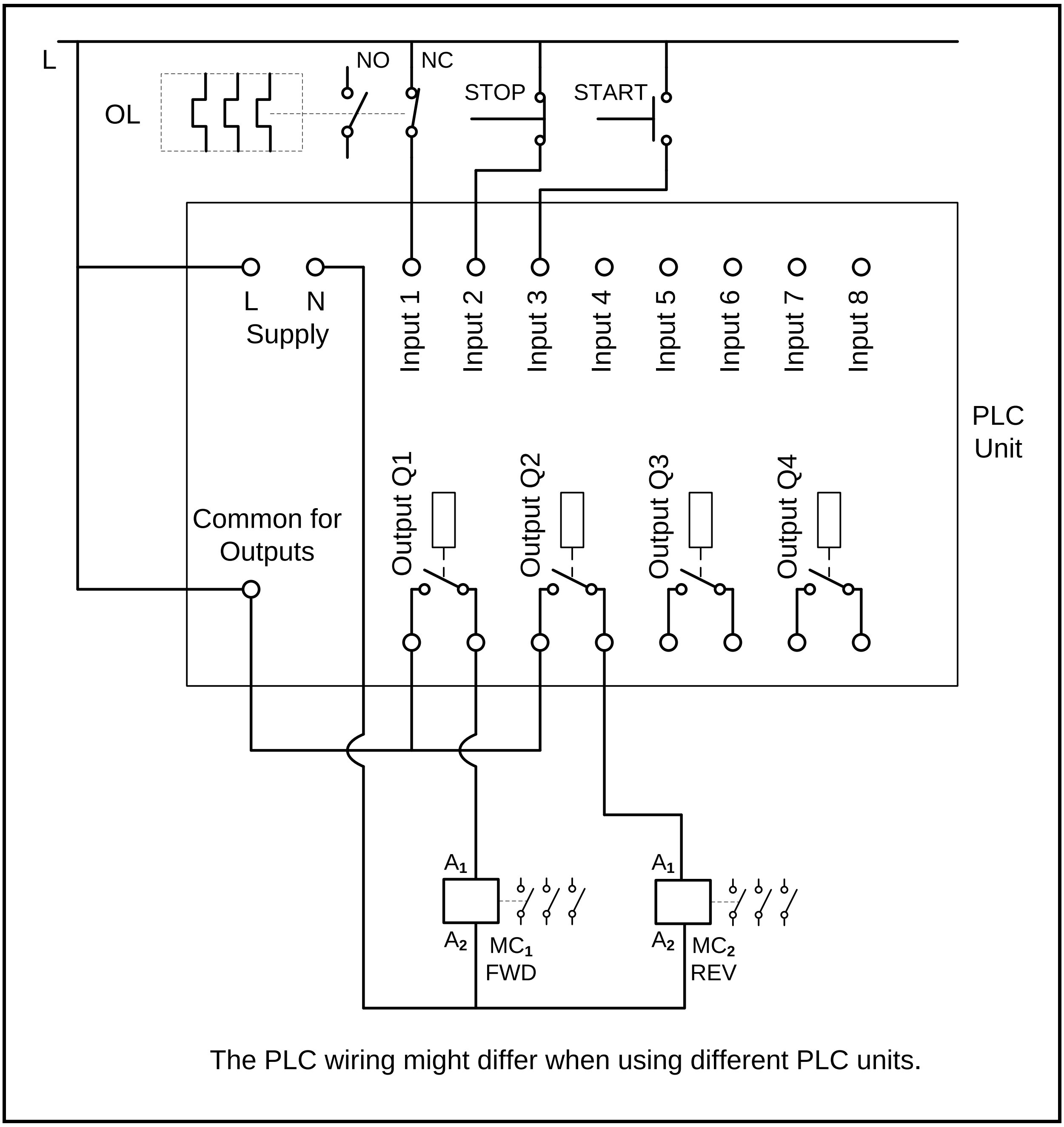


FIGURE 4.4.1(b): PLC UNIT CONNECTED TO THE CONTROL CIRCUIT

Inputs to the PLC

X1/I01 = O/L
X2/I02 = Stop button
X3/I03 = Start button

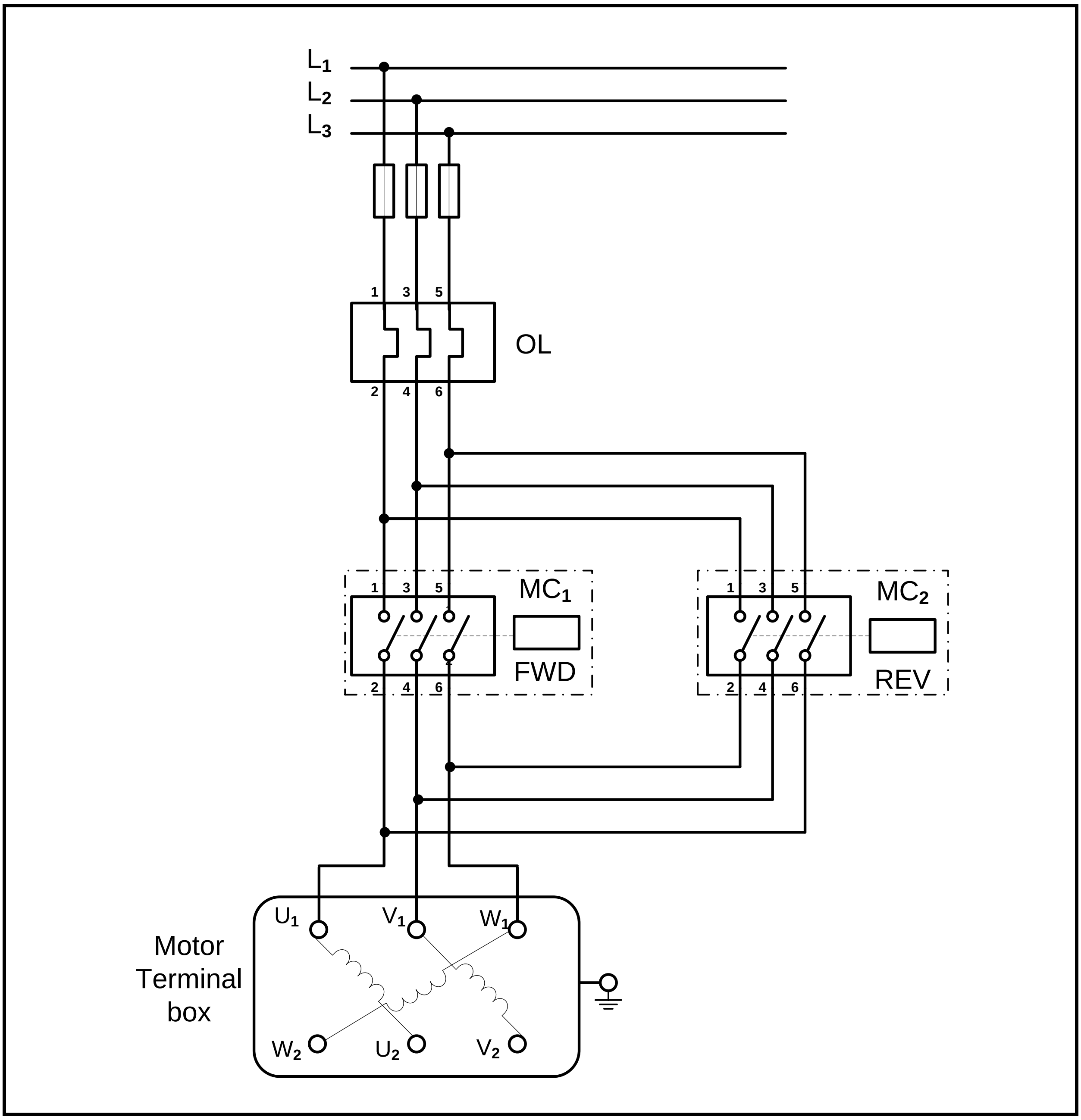


FIGURE 4.4.1(c): FORWARD-REVERSE POWER CIRCUIT

4.4.2 **Resources Required**

TOOLS/INSTRUMENTS	MATERIALS
Multimeter/Clamp meter or continuity tester	Connecting wires
Computer/Programmer	PLC unit
Programming cable	1 x three-phase induction motor
Wire-stripper	1 x three-phase overload relay
Long-nose pliers	1 x stop button
Screwdriver	1 x start button
Side cutters	2 x three-phase contactors

4.4.3 **Procedure**

- Convert the relay logic circuit in FIGURE 4.4.1(a) into a ladder logic program.
- Program the ladder logic diagram through a computer.
- Run the PLC program in the computer and simulate the operation.
- Load the program from a computer to a PLC.
- Ensure the PLC is in run mode.
- Disconnect the programming cable.
- Switch off the supply.
- Connect the PLC to the control the circuit.
- Only switch ON the supply after your teacher has checked the circuit and confirmed it as correct.
- If the program and control circuit is working, switch OFF the power supply.
- Wire the power circuit to the motor.
- Ask your teacher to check the wiring of the power circuit before switching it ON.
- The teacher will insert faults on the PLC and the learner must identify and correct them.
- Ask your teacher to inspect the circuit and ensure that all faults are corrected.

4.4.4 (a) Take a snapshot (screenshot) of the programmed ladder logic diagram. Save, print and paste it in the blank space below. Ensure that your name and the circuit name appear in the title block of the circuit.

(10)

(b) Explain the purpose of interlocking in this motor starter. (2)

[12]

FACET SHEET FOR SIMULATION 4: THREE-PHASE FORWARD-REVERSE MOTOR CONTROL STARTER WITH OVERLOAD USING PLC

FACETS	FACET 1	FACET 2	FACET 3	FACET 4	MAXIMUM POSSIBLE MARKS	LEARNER'S MARK
Preparation of the simulation	Testing the functionality of all devices to be used (stop/start buttons, contactors etc.) **(1)**	Correctly identifying and collecting all contactors and components **(1)**	Correctly identifying and collecting all tools and measuring instruments **(1)**		**3 marks max.**	
PLC unit	Develop the ladder logic diagram in the computer correctly **(1)**	Correctly connecting the PLC unit to control the circuit with: No assistance **(5)** Assistance once **(4)** Assistance more than once **(2)**	Correctly loading the program from the computer to the PLC unit: Without assistance **(2)** With assistance **(1)**	Run the program to test the control circuit: Without assistance **(2)** With assistance **(1)**	**10 marks max.**	
Operation of the control circuit	Control circuit worked partially **(2)**	Circuit worked correctly **(5)**			**5 marks max.**	
Fault finding	The faults were correctly identified **(1)**	The faults were corrected without assistance **(2)** The faults were corrected with assistance **(1)**			**3 marks max.**	
Wiring of power circuit	Correct procedure in wiring the circuit **(1)**	Correct colour coding. Main circuit. (L1 red, L2 yellow, L3 blue) **(1)**	Correctly connecting the power circuit with: No assistance **(5)** Assistance once **(4)** Assistance more than once **(2)**	Testing continuity in the circuit **(1)**	**8 marks max.**	
Operation of the power circuit	Power circuit worked partially **(2)**	Power circuit worked correctly **(5)**			**5 marks max.**	
Safety	Safety precautions were observed after being reminded **(1)**	Safety precautions were observed without being reminded **(2)**			**2 marks max.**	
Housekeeping	Housekeeping was practised after being reminded **(1)**	Housekeeping was practised without being reminded **(2)**			**2 marks max.**	
				ACTIVITY FOR SIMULATION 4:	**(12)**	
				FACET SHEET FOR SIMULATION 4:	**(38)**	
				TOTAL:	**[50]**	

5. SECTION B – DESIGN AND MAKE

Design and Make Project

Time: January to August 2022

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

5.2 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.	5	
2.	The circuit diagram was drawn using CAD/any electronic design software.	1	
3.	The circuit diagram was drawn using correct symbols.	3	
4.	The circuit diagram has all labels – R1, C1, Tr1, etc.	3	
5.	The circuit diagram has all component values –100 Ω, 220 μF, etc.	4	
6.	The circuit diagram has a name/title.	2	
7.	The circuit diagram has a frame and title block. (EGD approach).	2	
	Circuit Diagram Subtotal:	**20**	
Component List			
8.	Labels correlate with circuit diagram.	2	
9.	Description and values correlate with circuit diagram.	2	
10.	Quantities are correct.	1	
	Component List Subtotal:	**5**	
Description of Operation			
11.	Basic function of the circuit is described correctly.	10	
12.	All subcircuits in the circuit diagram and component list are included in the description.	5	
13.	Purposes of subcircuits in the circuit diagram are described correctly.	5	
14.	Learner used own interpretation and did not copy from another source verbatim.	4	
15.	Sources are acknowledged.	1	
	Description of Operation Subtotal:	**25**	
Tools/Instrument List			
16.	The tools/instrument list has been completed.	4	
17.	The tools/instruments listed all have a purpose for being used.	1	
	Tools/Instrument List Subtotal:	**5**	

NO.	FACET DESCRIPTION	Mark	Achieved = 1 Not achieved = ✗
Circuit Board Manufacturing			
18.	Transfer of the PCB design onto the blank board is correct. Not over exposed or under exposed.	5	
19.	Circuit board is etched neatly according to the PCB design.	10	
20.	The learner's name is etched onto the circuit design.	4	
21.	All burrs are removed.	2	
22.	Axial and radial components are placed neatly and flush with the board.	5	
23.	Component orientation are aligned between similar components (e.g. the gold band of all resistors are placed on the same side).	2	
24.	Soldered components – leads are cut off, flush and neat on the solder side.	5	
25.	More than 60% of the solder joints are shiny (not dry joints).	5	
26.	Wire insulation is stripped to the correct length (no extra copper showing).	3	
27.	Wiring is long enough to allow for dismantling and inspection.	2	
28.	Wiring is wrapped neatly.	2	
29.	A power switch is included and fitted to the enclosure.	2	
30.	Wiring entering/exiting the enclosure is provided with a grommet/applicable fittings/sockets where applicable.	2	
31.	A fuse/Protection is included and fitted correctly where applicable.	2	
32.	Batteries/Transformer is mounted using a battery housing/ mounting bracket and battery clip (NO double-sided tape).	2	
33.	The project has a pilot light/LED installed in the enclosure showing when the circuit is operational. LED is mounted with a grommet or applicable fitting. (Switch is on – must go out when fuse is blown.)	2	
34.	The project is fully operational and commissioned/installed in the enclosure.	10	
	Circuit Board Manufacturing Subtotal:	**65**	
	Circuit Diagram Subtotal:	**20**	
	Component List Subtotal:	**5**	
	Description of Operation Subtotal:	**25**	
	Tools/Instrument List Subtotal:	**5**	
	Circuit Board Manufacturing Subtotal:	**65**	

TOTAL (PART 1 = 120 marks)	

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

5.3 **Design and make: Part 2**

5.3.1 **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.

5.3.2 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.

5.3.3 Choose a name for your device.
Write down the name of the device below.

____

5.3.4 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.	2	
2.	Drawn design includes a title box and page border.	1	
3.	Isometric drawing included additionally.	2	
4.	Dimensions are included.	2	
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	
	Enclosure Design Subtotal:	**10**	
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.	2	
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).	2	
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	5	
12.	Holes/Cut-outs in the enclosure are made with the appropriate tools.	3	
13.	Specification plate with the learner's name, operating voltage, fuse rating and additional information on the project.	2	
14.	Enclosure is neatly prepared, 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.)	2	
	Enclosure Manufacturing Subtotal:	**20**	

TOTAL (PART 2 = 30 marks)	

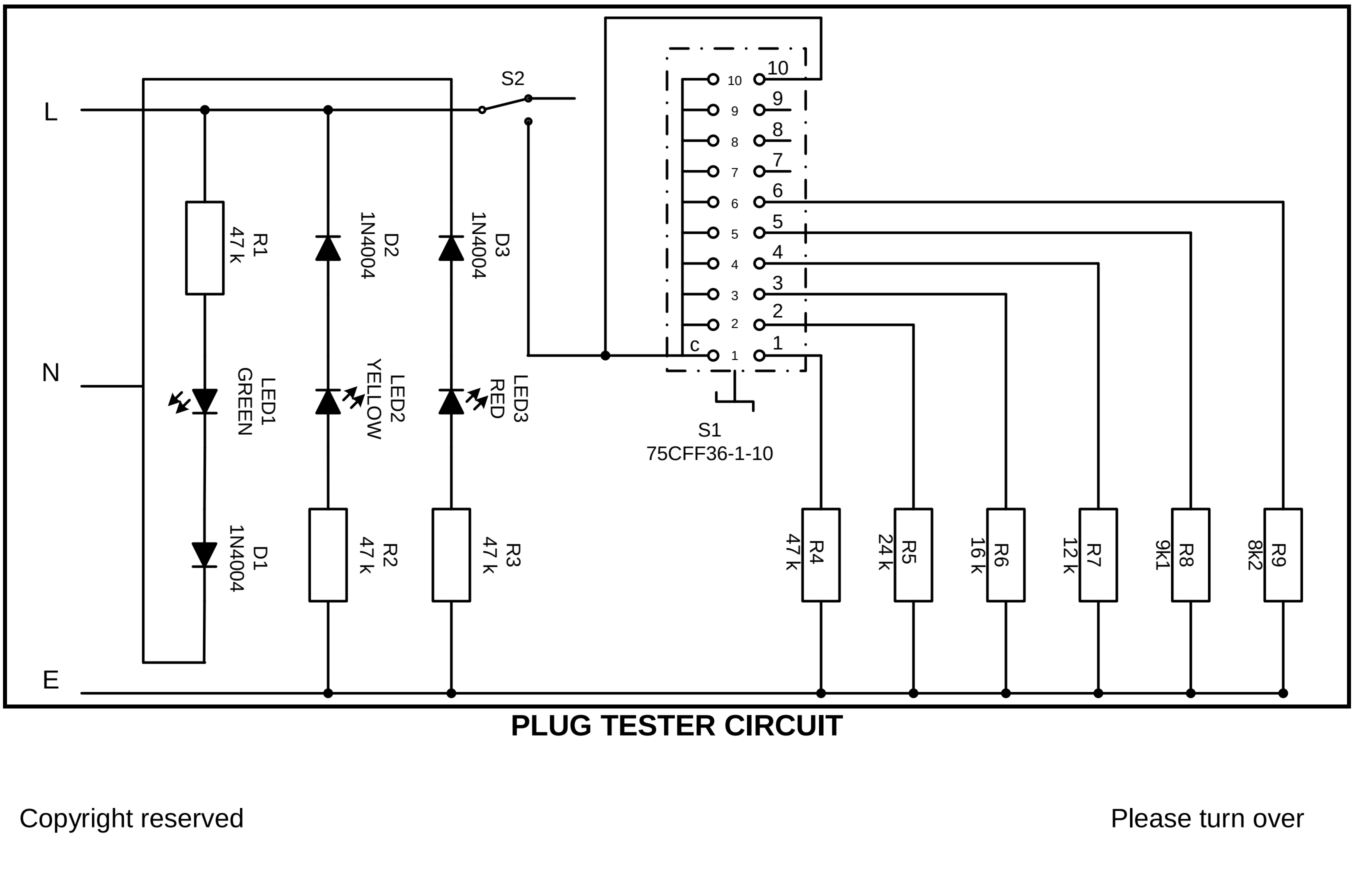
6. PROJECTS

6.1 Practical Project 6.1: Plug Tester

The plug tester is a handy device you can build yourself and will provide you with years of good service.
When installing and commissioning or when repairing plug circuits at home, it is advisable that you test your circuit before you switch it on. This is not the end however, even after you have switched on, there are so tests that are indispensable. Contrary to popular belief, it DOES make a difference when connecting alternating current supply to a plug and or light circuit. The LIVE is the current carrier and is at a higher potential than earth and neutral. It is imperative that the switch that controls any AC circuit is connected to the LIVE line. Follow this LED sequence when connecting the plug of the DIY Plug Tester to the plug being tested.
In all AC installations, there is, or should be, an earth leakage protection relay. These devices are typically calibrated to trip and disconnect the supply in case of current leaking to ground through a connection it is not intended for.
It is advised that the earth leakage be tested once every 6 months to ensure that it has not been damaged by lightning or power surges, which is not uncommon in a load-shedding scenario.
By introducing a leakage current between LIVE and EARTH, the earth leakage can be checked. The leakage current values are determined using Ohm's law.

The assumption is made that your supply voltage is 240 volts AC. To determine the leakage current complete the table below: $I_{Leakage} = VAC_{\ Mains}/R_{Leakage\ Resistor}$

RESISTOR	LEAKAGE CURRENT BEING TESTED
47K	5,1 mA
24K	10 m
16K	15 mA
12K	2 mA
9K1	26,37 mA
8K2	29,26 m



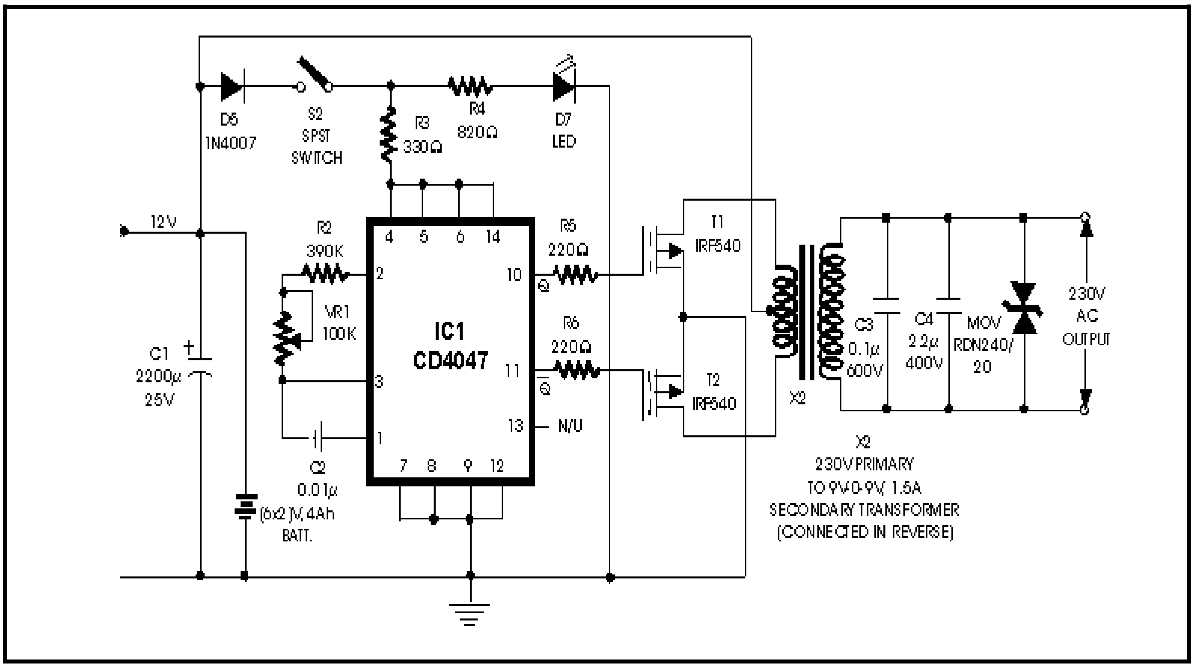
PLUG TESTER CIRCUIT

COMPONENT LIST		
PART	**VALUE**	**DESCRIPTION**
D1	1N4004 / 7	Diode
D2	1N4004 / 7	Diode
D3	1N4004 / 7	Diode
LED1	GREEN	LED5MM
LED2	YELLOW	LED5MM
LED3	RED	LED5MM
R1	47k 2W	Resistor
R2	47k 2W	Resistor
R3	47k 2W	Resistor
R4	47k 2W	Resistor
R5	24K	Resistor
R6	16K	Resistor
R7	12K	Resistor
R8	9K1	Resistor
R9	8K2	Resistor
S1	75CF36-1-10	Single-deck rotary switches
S2	Test button	N/O push switch
4		PCB mount with M3 screw and nut
1		Solder wire
1 m		Cab tyre
1		3-pin plug

6.2 Practical Project 6.2: 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

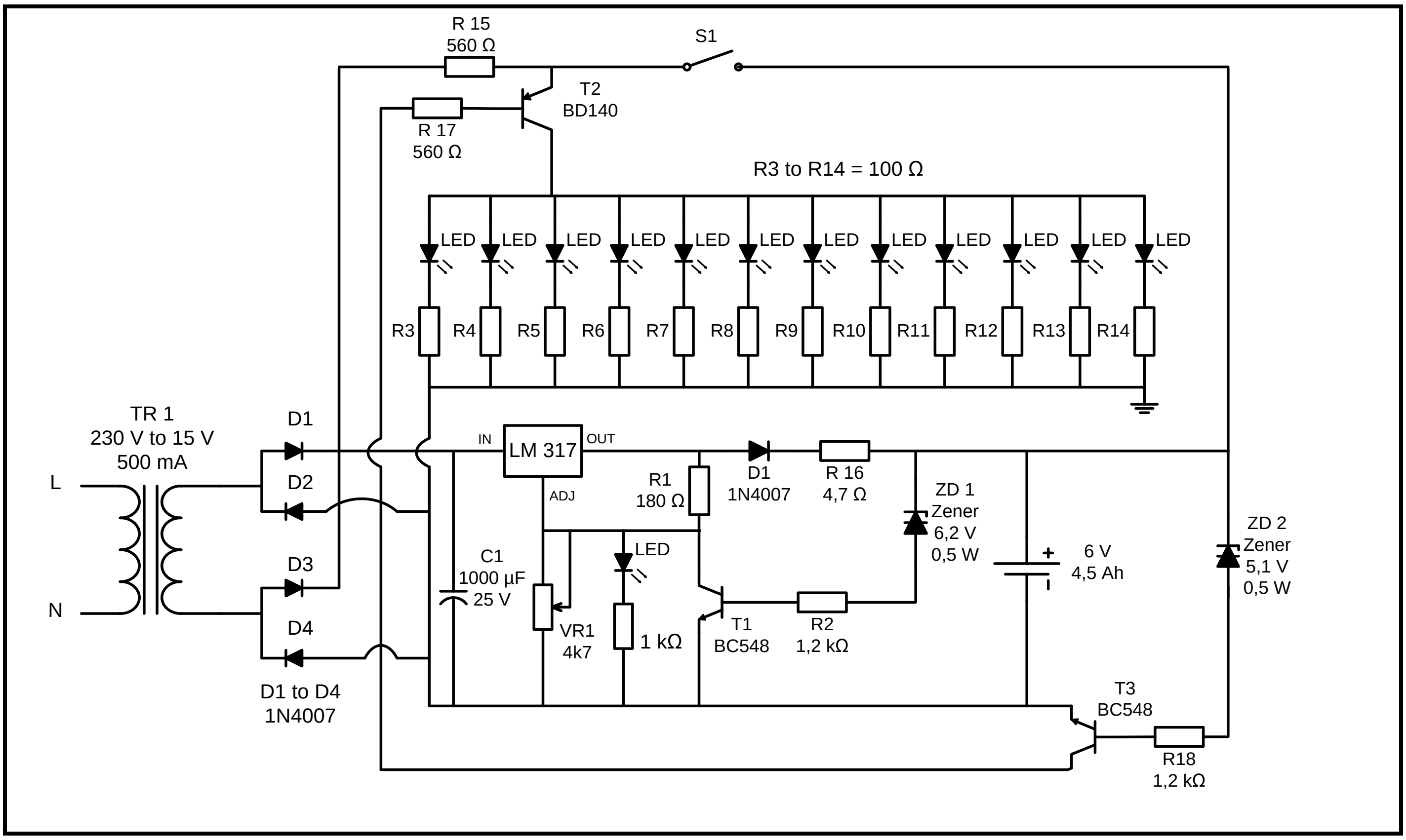
COMPONENT LIST

Diode	1N4007	VR1	100 KΩ
C1	2 200 µF	R2	390 KΩ
C2	0,01 µF	R3	330 Ω
C3	0,1 µF	R4	820 Ω
C4	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.			

6.3 Practical Project 6.3: Automatic LED emergency light

This project consists of TWO sections

1. LED lamp circuit
2. The battery charger circuit



AUTOMATIC LED EMERGENCY LIGHT

LED lamp circuit

- All are white hi-bright LEDs rated for 3 volts @ 25 mA.
- The total current requirement is 12 x 25 = 300 mA.
- This current has to flow through a T2 – BD140 PNP transistor.
- The minimum current gain (hfe) of this transistor @ 500 mA is 50.
- Hence the base current Ib requirement is Ic/hfe, 300/50 = 6 mA.
- Base emitter drop of T2 at 500 mA is 0,77 volts.
- With the fully charged battery at 6,9 volts terminal voltage (for cycle operation use) the voltage available across the new bias resistance is (6,9–0,77).
- Hence the bias resistance is = 6,13/6 = 1 000 ohms.
- As the battery drains the final terminal voltage will be 5,4 volts.
- The bias resistance will be (5,4–0,77)/6 = 770 ohms. Hence 680 ohms was preferred for bias resistance with drained battery, also it will give enough brightness.
- The very important information about BD140 is, as you view the pins, metal portion of the transistor facing down left is emitter centre collector and right is base. Most of the constructors make this mistake, relying on the convention that left base and right emitter. If you have made this mistake, correct it.
- Once this portion is checked for reliable operation we will proceed to charger portion.

The battery charger circuit

- The battery requires a full terminal voltage of 6,9 V, at this point the charger should cut off.
- That is the voltage across the chain ZD1, R2 and T1 should be 6,9 volts.
- T1 be voltage of 0,7 volts plus drop across R2 and Zener voltage should be 6,9 V.
- T1 is current = Ic/hfe.
- Ic is 1,25/180 = 7 mA.
- Ibe = Ic/hfe of T1, i.e. = 7/70 = 100 uA.
- Drop across R2 =1,2 x,1 mA = 0,12 volts.
- Hence Zener voltage = 6,9 – (0,7 + 0,12) = 6,08 the nearby preferred Zener voltage is 6,2 volts.
- Say the battery voltage at full charge will be 7 volts with 6,2 volts Zener diode.
- To calculate the R16 value for charging at 1/10th of the rated current of the battery 4,5 AH/10 = 450 mAH.
- Transformer 9 volts AC the voltage across C1 will be 9 x 1,414 = 12,6 volts.
- The drop across LM317 at 450 mA current for good regulation is 3 volts.
- The drop across protective diode D5 is 0,7 volts.
- The voltage available at cathode of D5 is 12,6 – (3 + 0,7) = 8,9 volts.
- The battery after fair discharge will be at 6 volts.
- Hence R16 = (8,9 – 7)/0,45 = 6 ohms.
- The nearby standard value for operation is 5 ohms.
- At the end point of battery 5,4 volts the maximum charging current can be of (8,9 – 5,4)/5 = 0,7 amps well within the higher charging limit of the battery.
- With this circuit overnight the battery will get charged fully.
- Overcharging is taken care and protected by T1.

NOTE: All circuits MUST include an ON/OFF switch with an 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.