basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

ELECTRICAL TECHNOLOGY

GUIDELINES FOR PRACTICAL ASSESSMENT TASKS

2018

These guidelines consist of 79 pages.

TABLE OF CONTENTS

1. INTRODUCTION

The 16 Curriculum and Assessment Policy Statement 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
- 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-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 uses a technological process to inform the learner what steps needs to be followed to derive a solution for the problem.

The 2018 PAT has three focus areas with projects and simulations in each of the following fields:

- Electrical
- Electronics
- Digital Electronics

The PAT consists of four simulations and a practical project. The teacher may choose any of the practical projects and use a combination of the simulations available.

The teacher has to apply assessment on an on-going 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 from Grades 10, 11 and 12. The PAT ensures that all the different skills will be acquired by learners on completion of practical work, that is electrical, electronics and digital electronics 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 2018 cover page and the relevant simulations and assessment sheets should be given 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 budget and school management teams are required to make provision to accommodate this particular expense.

PAT components and other items must be acquired timely 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 the 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. All formal assessment is the teacher's responsibility.

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 to leave the workshop and must be kept in a safe place at all times when the learner is not working on it.

Adhere to the weightings of the PAT and teachers are not allowed to change the weightings for the different sections.

2.2 How to mark/assess the PATs

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

The teacher is required to produce a **working model and model answer file** which 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 standard required 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 2018	Teacher – Builds the models and works out the model answers for the simulations for 2018. Identify shortages in tools, equipment and consumable items for simulations which must be procured in 2018. SMT – Receive procurement requests from teachers and process payments for the acquisition of required items.
January–March 2018	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 2018	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 up on teacher to see if the process is being adhered to.
February 2018	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 PAT project every week. Learners – Commence with completion of the PAT project. HOD – Checks on teacher to ensure that practical workshop sessions take place on a weekly basis.
April–June 2018	Moderation of Simulations 1 and 2	District Subject Facilitator/Subject Specialist will visit the school and moderate Simulations 1 and 2. 10% of learners' work is moderated.
April–June 2018	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 2018	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 PAT project every week. Learners – Continue with completion of the PAT project. HOD – Checks on teacher to ensure that practical workshop sessions take place on a weekly basis.
July holiday 2018	PAT intervention	Learners that are behind on the PAT are required to complete the project during this holiday.
July–August 2018	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 2018	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 PAT files and project are completed and assessed
September–October 2018	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 at random.

2.4 Moderation of the 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, however, will 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 being moderated will have access to their file 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 select, at random, not 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 also 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

In 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 the outstanding task(s). 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 which the learner will have to build, test and measure and do practically as part of the development of practical skills. These skills have to be illustrated to the external moderator who visits the school at intervals during the school year.

Teachers who use simulation programs on computer are welcome to use them for the learners to practise 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 to complete 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 examples provided.
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 because they are lost or 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: Store the components. 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 will lead to components being used incorrectly. 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 portfolio.

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

2.7 Projects

The projects are construction projects teachers can choose for their learners. These projects are based on circuits provided by schools and subject advisors. The projects are based on working prototypes and require careful construction in order for it 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 circuit provided 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 circuit provided. 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/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				
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	Total = Term1 + Term 2 + Project 250	Mark out of 100	Moderated Mark
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
	Total									
	Average									

Teacher Name: ______________
Signature: ___________________
Date: ______________________

Principal Name: ______________
Signature: ___________________
Date:________________________

Moderator Name: _____________
Signature: ___________________
Date:__________________

School Stamp

3. LEARNER GUIDELINES

PAT 2018 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: Term 1 to Term 3 (2018)

Learner Name: ______________________________

Class: ______________________________

School: ______________________________

Specialisation (Tick your specialisation)
Electrical (Power Systems) - ☐**(Simulation 1, 2, 3, 4, 5 and 6) Any 4**
Electronics - ☐**(Simulation 1, 2, 7 and 8)**
Digital Electronics - ☐**(Simulation 1, 2, 7 and 8)**

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	50		
Simulation 2	50		
Simulation 3	50		
Simulation 4	50		
Design and Make Project – Circuit	40		
Design and Make Project – Enclosure	10		
Total	**250**		

3.1 **Instructions to the learner**

- This PAT 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 PAT must be completed over three terms.
- 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 decimals. SI units should be used.
- Circuit diagrams may be hand-drawn or drawn on CAD. NO photocopies or scanned files are allowed.
- Photographs are allowed and may be in colour or grey scale. Scanned photographs and photocopies are allowed.
- Learners with identical photographs will be penalised and receive zero (0) 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 evidence is entirely my own effort. I understand that if proven otherwise, my final results will be withheld.

________________________ ____________
Signature of learner Date

4. SIMULATIONS

4.1 Simulation 1: RLC circuit

Specialisation:	Power Systems ☑	Electronics ☑	Digital ☒

Name of learner: ______________________________

Class: ___________ **Date Completed:** _____________ **MARK** ______ / 40

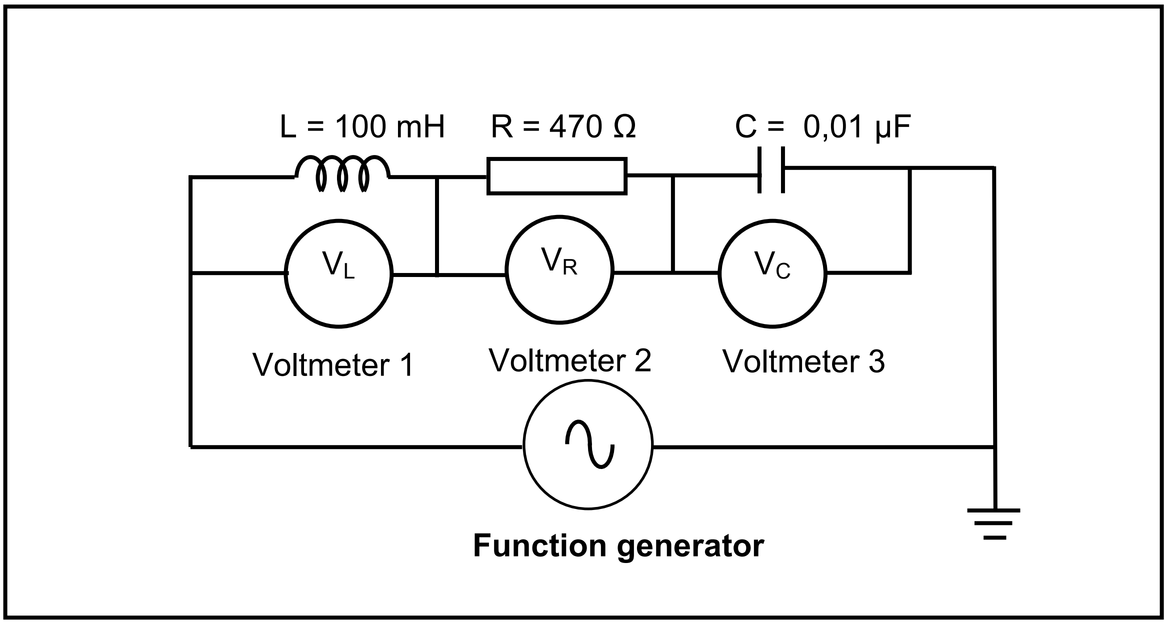
Date Assessed: _______________ Assessor Signature: _________________

Date Moderated: ______________ Moderator Signature: ______________________

PURPOSE:

To show the effect of changing frequency in an RLC circuit toward resonance.

ACTIVITY 1A: How V_C and V_L vary with frequency in a series RLC circuit



REQUIRED:

TOOLS/INSTRUMENTS	CONSUMABLES
Breadboard/… Dual-channel Oscilloscope Function Generator Multimeter (analog/digital) Side cutters	470 Ω resistor 0.01 μF capacitor 100 mH inductor Connecting wires

PROCEDURE:

1. Set the function generator to a sine wave and adjust the voltage to 5 V. Once the voltage is set do not change the amplitude setting of the voltage until all the experiments have been done.
   Set the amplitude settings on the oscilloscope to the same for both channel 1 and channel 2.

   Construct the circuit. Connect the multimeters and function generator, as shown in the RLC series circuit.

2. Adjust the frequency of the function generator until the voltmeter reading across the inductor and capacitor are the same. Record the reading of the voltages across each component and of the frequency on the table below.

Reading of the frequency and voltages on the meters	
V_L	=
V_C	=
V_R	=
f	=

   NOTE: Readings on this table will be taken as reference values. (4)

3. Adjust the frequency above the **reference values**.
   Record the reading of the voltages across each component and of the frequency in the table below.

Reading of the frequency and voltages on the meters	
V_L	=
V_C	=
f	=

(3)

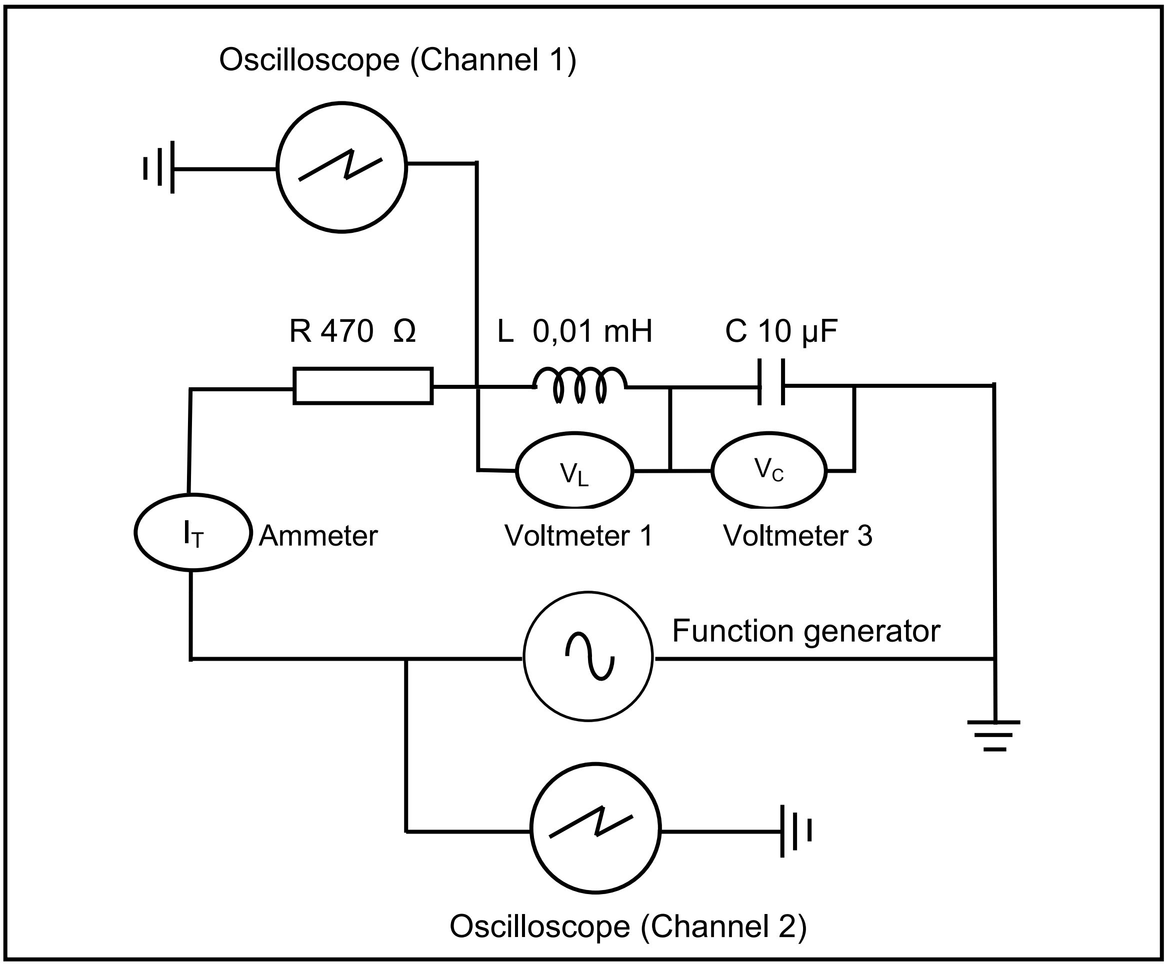
4. Adjust the frequency below the **reference values**.
   Record the reading of the voltages across each component and of the frequency on the table below.

Reading of the frequency and voltages on the meters	
V_L	=
V_C	=
f	=

(3)

5. Connect the multimeters, oscilloscope and the function generator as shown on the RLC series circuit.

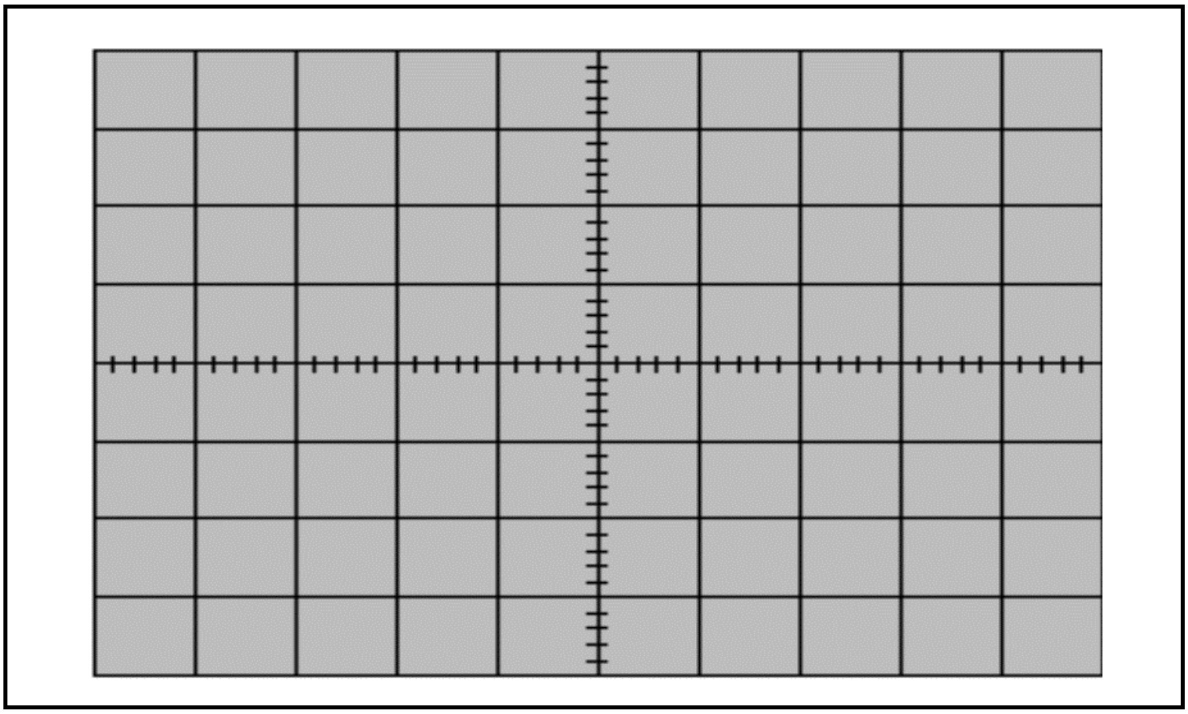
6. Adjust the frequency of the function generator until the reading across the inductor and capacitor are the same again. Record the readings on the voltmeters and ammeter and of the frequency on the table below.



Reading on the meters	
V_L	=
V_C	=
I_T	=
f	=

(2)

7. Draw the shape of the waveforms on the oscillogram. (4)



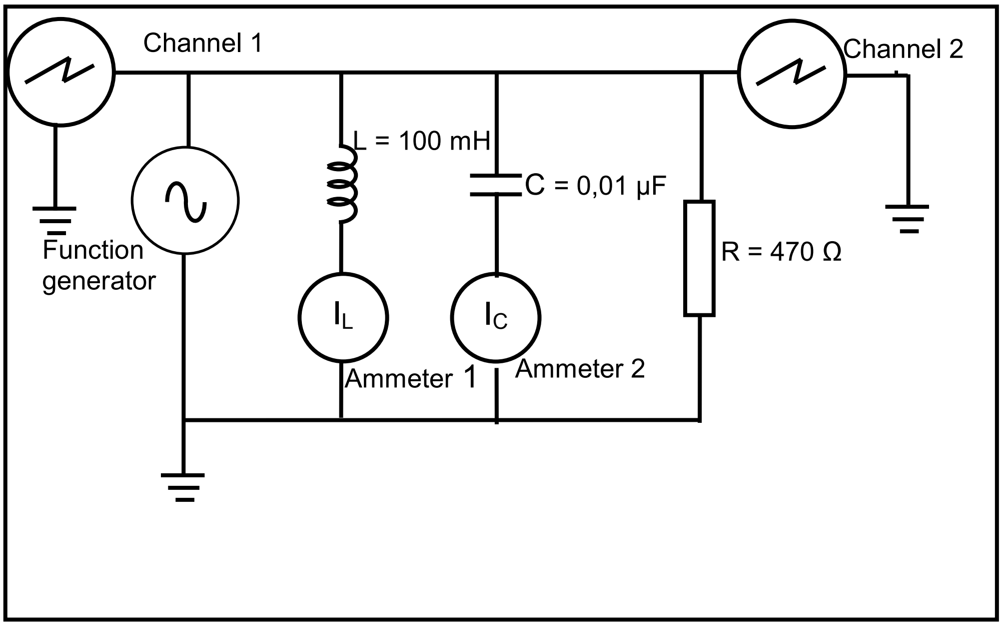
8. **CONCLUSION:**

With reference to the values in the tables and the waveforms on the oscillogram, describe the responses of the voltages across each component when the frequency is adjusted above and below **reference values**.

(4)

SUBTOTAL – ACTIVITY A: [20]

ACTIVITY 1B: How I_C and I_L vary with frequency in a parallel RLC circuit



REQUIRED:

TOOLS/INSTRUMENTS	CONSUMABLES
Breadboard/...	470 Ω resistor
Dual-channel Oscilloscope	0.01 µF Capacitor
Function Generator	100 mH inductor
Multimeter (analog/digital) x 3	Connecting wires
Side cutters	
Wire stripper	

PROCEDURE:

1. Set the function generator to a sine wave and adjust the voltage to 5 V. Once the voltage is set do not change the amplitude setting of the voltage.
   Set the amplitude settings on the oscilloscope to the same for both channel 1 and channel 2.
   Connect the multimeters and function generator, as shown in the RLC series circuit.

2. Adjust the frequency of the function generator until the reading on ammeter 1 and ammeter 3 are the same. Record the reading through each component and of the frequency in the table below.

Readings on the ammeters	
I_L	=
I_C	=
I_R	=
f	=

NOTE: Readings on this table will be taken as reference values. (4)

3. Adjust the frequency above the **reference values**.
Record the values of the currents through the inductor and the capacitor and the frequency on the table below.

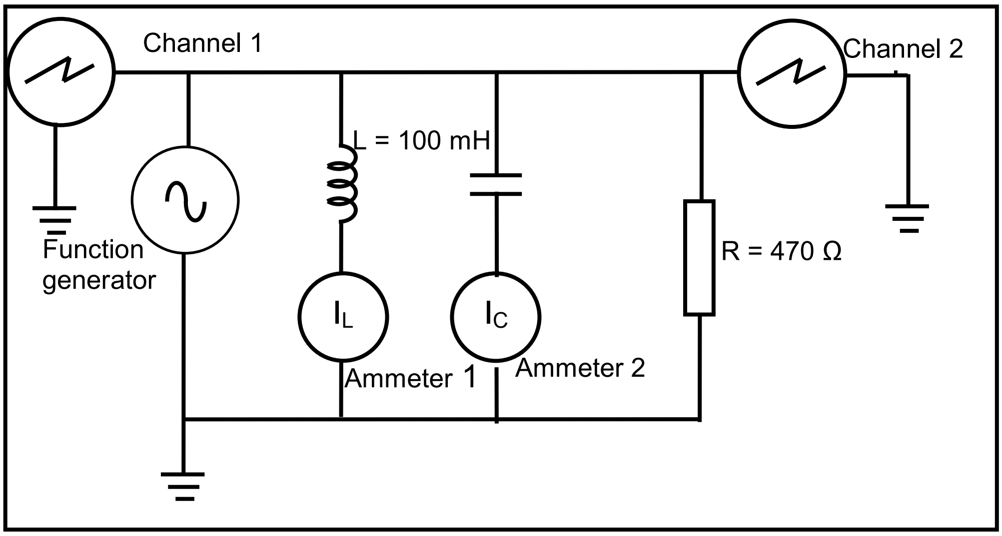
Readings on the ammeters	
I_L	=
I_C	=
f	=

4. Adjust the frequency below the **reference values**.
Record the values of the current through each component and of the frequency on the table below.

Readings on the ammeters	
I_L	=
I_C	=
f	=

PROCEDURE

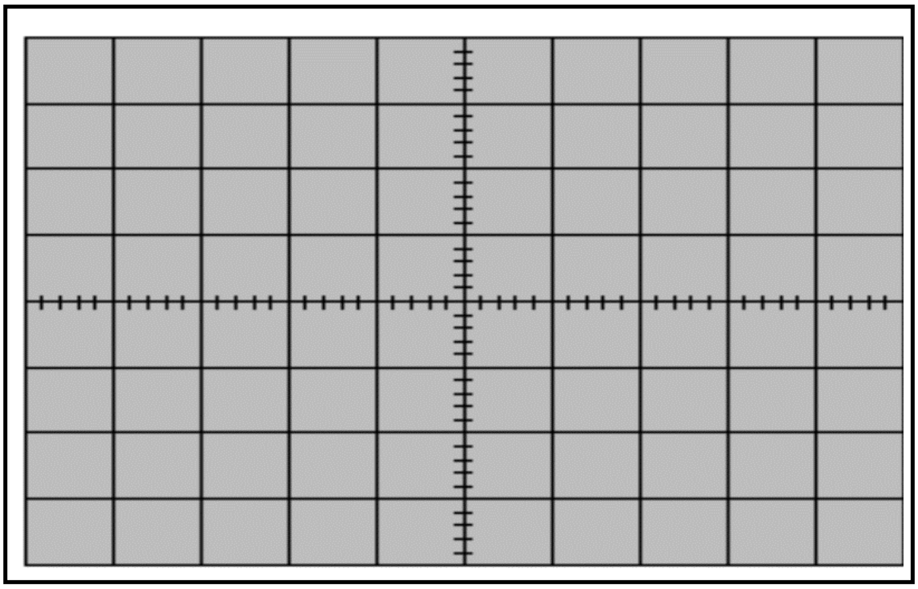
Connect the multimeters, function generator and the oscilloscope, as shown in the circuit below.
Adjust the frequency of the function generator until the reading through the inductor and a capacitor are the same. Record the readings through the ammeters and of the frequency on the table below.



Readings on the ammeters	
I_L	=
I_C	=
f	=

(3)

Draw the shape of the waveforms on the oscillogram.



CONCLUSION:

With reference to the values on the table and of the waveforms on the oscillogram, describe the responses of the current through each component when the frequency is adjusted above and below **reference values**. (3)

[20]

SUBTOTAL – ACTIVITY 1A: 20
SUBTOTAL – ACTIVITY 1B: 20
TOTAL: 40

4.2 Simulation 2: Connecting three single-phase transformers to a three-phase supply

Specialisation:	*Power Systems* ☑	*Electronics* ☒	*Digital* ☒

Name of learner: ________________________________

Class: ____________ **Date Completed:** _______________

MARK ____________ / 40

Date Assessed: ________________ Assessor Signature: ___________________

Date Moderated: ________________ Moderator Signature: _________________________

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 consist of three identical incandescent lamps that are connected in delta
- To measure the primary and secondary line and phase voltages and currents

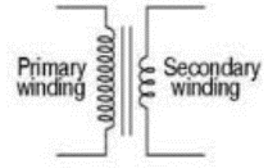
REQUIRED:

TOOLS/INSTRUMENTS/DEVICES	CONSUMABLES
Three identical step-down single-phase transformers A three-phase supply Clamp meter and multimeter Wire-striper Long nose pliers Screw driver Side cutters	Connecting wires Three identical incandescent lamps

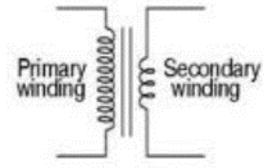
PROCEDURE:

1. Connect the primary windings of each transformer to the supply and the secondary to the load (lamp).
   Complete the table below 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 (neutral and live).

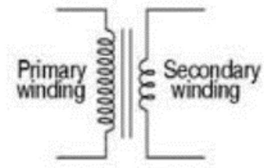
A



B



C



Transformer	Primary voltage	Secondary voltage
A	V_{Prim} =	V_{SEC} =
B	V_{Prim} =	V_{SEC} =
C	V_{Prim} =	V_{SEC} =

(6)

2. Calculate the transformer ratio of each single-phase transformer using voltage values from the table above.
   Explain whether these three transformers can be connected in star-delta configuration.
   NOTE: Your answer must be informed by transformer ratio calculations. (11)

3. Draw the circuit diagram in which these transformers are connected in a star/delta configuration using the colour coding and label it correctly.

(4)

4. 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 are compatible.
- It is the duty of the teacher to verify that the learners are connecting 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.
- Schools using older panels that are closed up and schools with no clamp meters should measure the primary line and phase voltages only.

5. Measure the primary and secondary line and phase voltages and currents. Record the reading on the table below.

Primary side			Secondary side	
Reading between line voltages, neutral and line currents			Reading between line voltage and line current	
V_{L1} & V_{L2} =	V_{L1} & N =	I_{L1} =	V_{L1} & V_{L2} =	I_{L1} =
V_{L1} & V_{L2} =	V_{L2} & N =	I_{L2} =	V_{L1} & V_{L2} =	I_{L2} =
V_{L1} & V_{L2} =	V_{L3} & N =	I_{L3} =	V_{L1} & V_{L2} =	I_{L3} =

(15)

CONCLUSION:

Your conclusion must be based on the table above and other observations. (4)

[40]

4.3 Simulation 3: Inspecting and testing the AC motor

Specialisation:	*Power Systems* ☑	*Electronics* ☒	*Digital* ☒

Name of learner: ______________________________

Class: ___________ **Date Completed:** ______________

MARK ______ / 40

Date Assessed: _______________ Assessor Signature: __________________

Date Moderated: ______________ Moderator Signature: _______________________

PURPOSE:

To conduct the following tests:

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

REQUIRED RESOURCES:

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

PROCEDURE:

Use the list below to conduct an inspection tests on an AC electrical motor.
Complete the results in the table below.

ACTIVITY 1A:

1.1 Details on the nameplate of the motor being tested:

Phase:_________________ Supply voltage: __________

Pole pairs:____________________ Speed :_________________

Efficiency: ____________________ Current: ________________

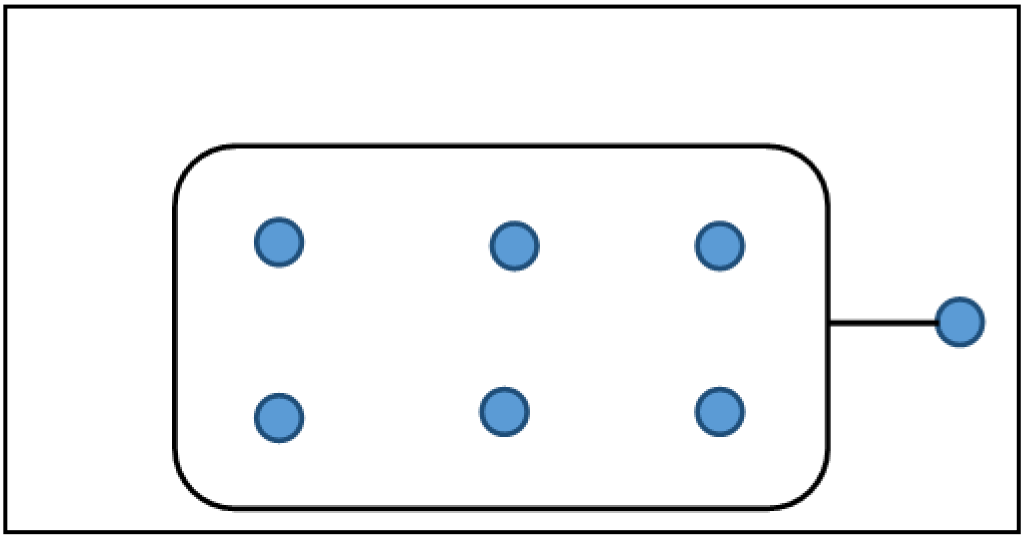
Power rating: _______________ Frequency:___________ (8)

ACTIVITY 1B: Complete the table below.

DESCRIPTION	VISUAL INSPECTION AND READINGS TAKEN (Megger)	MARKS ALLOCATED
Condition of windings: Measurements taken		
Test 1: Continuity of the windings (3 marks)		
A1 – A2		
B1 – B2		
C1 – C2		
Test 2: Insulation resistance between windings (3 marks)		
A1 – B1		
A1 – C1		
B1 – C1		
Test 3 – Insulation resistance to earth (3 marks)		
A1 – Earth		
B1 – Earth		
C1 – Earth		
Test 4 – Mechanical inspection Note all errors (9 marks) (Short description)		
Condition of rotor and shaft		
Key/Key way		
Front bearing		
Back bearing		
Condition of motor frame (Short description)		
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)

1.2.2 Draw and label the correct connection of internal wiring on the diagram provided below. (This information must correspond with the internal wiring of the motor tested.)



(4)

1.2.3 According to the regulation, state the minimum acceptable values of the following:

1.2.3.1 Continuity test of the windings: (1)

1.2.3.2 Insulation resistance test between windings: (1)

1.3

Conducted Test	Acceptable/Not acceptable with reason
Winding resistance	
Insulation resistance	
Earth resistance	
Can the motor be used	

(8)
[40]

4.4 Simulation 4: DOL Starter

Specialisation:	*Power Systems* ☑	*Electronics* ☒	*Digital* ☒

Name of learner: ________________________________

Class: ____________ **Date Completed:** _______________ **MARK** ____ / 40

Date Assessed: _________________ Assessor Signature: ____________________

Date Moderated: ________________ Moderator Signature: _________________________

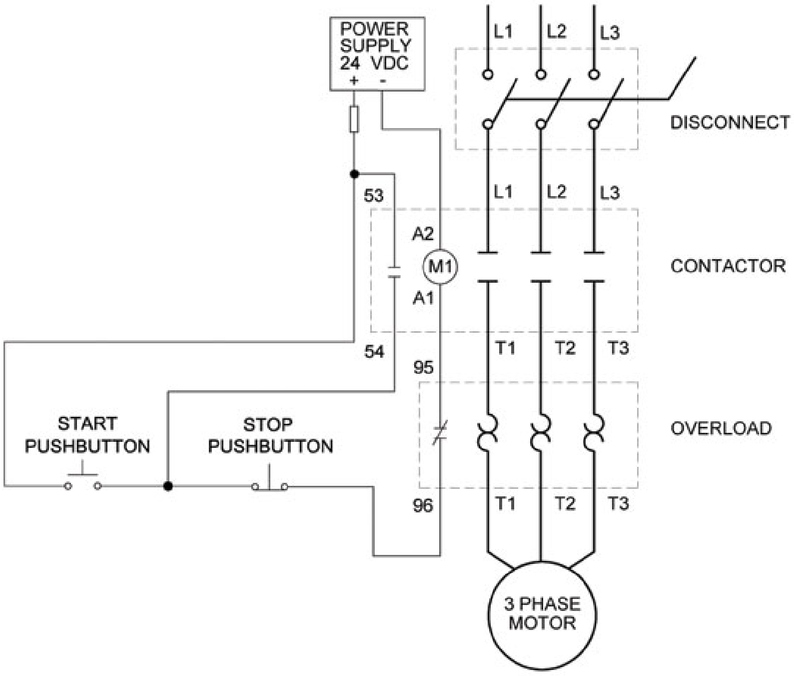
PURPOSE:

Practical simulation of a three-phase direct-on-line (DOL) starter

REQUIRED:

TOOLS/INSTRUMENTS	CONSUMABLES
1 x three-phase contactor with auxiliary contacts 1 x three-phase overload relay 1 x stop button 1 x start button 1 x 380 V delta induction motor (squirrel-cage motor) Correct wire size or plug in leads Wire stripper Long nose pliers Screw driver Side cutters	Multimeter or continuity tester 2 x pilot lights (red and green)

CONTROL AND POWER CIRCUIT OF THE DOL



PROCEDURE:

Wire the control circuit first; test it before wiring and connecting it to the power circuit.
Connect the motor to the power circuit and set the overload.
Now ask the teacher to check the circuits. When the circuits are correct switch the supply on and start the motor.
Stop the motor and switch the supply off.
Consider all safety aspect before and during the wiring process and be focused until the motor is cooperating.
The teacher will insert faults on the control circuit and the learner must identify them.

ACTIVITY 1A:

1.1 State why the normally hold-in contact is connected in parallel with the start button. (2)

1.2 Describe the functions of the following:

1.2.1 Overload relay (2)

1.2.2 Contactor (2)

1.3 State any TWO precautionary measures to adhere to when wiring the circuit. (2)

1.4 Change the direction of rotation of the motor and state your observation. (2)

1.5 State TWO applications of a DOL starter. (2)
[12]

FACET: Simulation 4: DOL starter

FACETS	FACET 1	FACET 2	FACET 3	FACET 4	MAXIMUM POSSIBLE MARKS	LEARNER'S MARK
Preparation of the simulation	Correctly interprets the wiring diagram of control and power circuit	Correctly identifies and collects all devices	Correctly identifies and collects all measuring instruments	Correctly identifies and collects all tools	8	
Wiring of control circuit	Tests the functionality of all devices to be used	Correct procedure in wiring the circuit	Tests continuity in the circuit	Operation of the circuit	8	
Wiring of power circuit	Tests the functionality of the motor	Correct procedure in wiring the circuit	Tests continuity in the circuit		6	
Setting of fault				Fault successfully identified	2	
Safety				Safety precautions were observed	2	
Housekeeping				Housekeeping was practised	2	
					(28)	
				Activity 1A	**(12)**	
				Facet	**(28)**	
				TOTAL	**40**	

4.5 Simulation 5: Three-phase sequence motor control starter with overload and timer using PLC

Specialisation:	*Power Systems* ☑	*Electronics* ☒	*Digital* ☒

Name of learner: ______________________________

Class: ____________ **Date Completed:** _______________

MARK ______ / 40

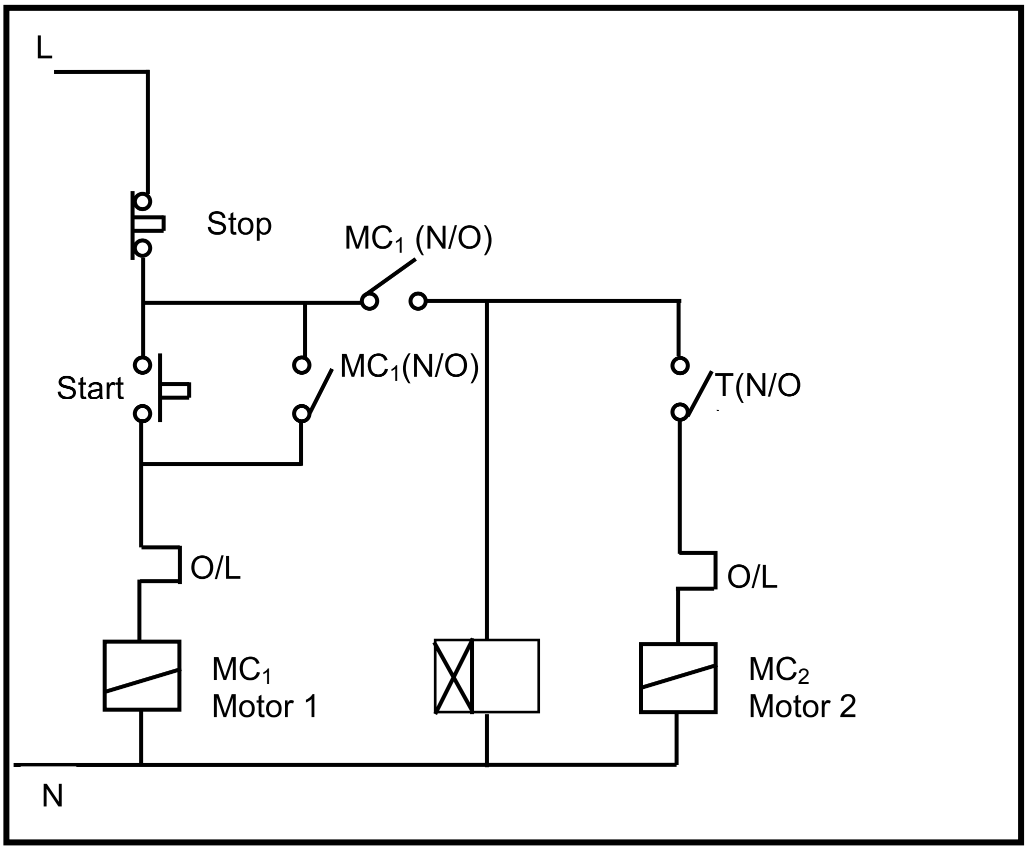
Date Assessed: ________________ Assessor Signature: ___________________

Date Moderated: ________________ Moderator Signature: ________________________

PURPOSE:

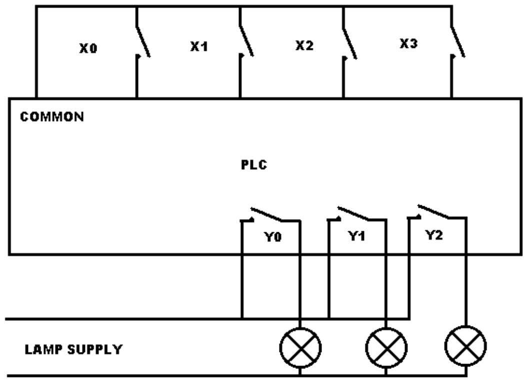
Practical simulation of a three-phase sequence motor control starter with overload and timer using PLC

Control circuit



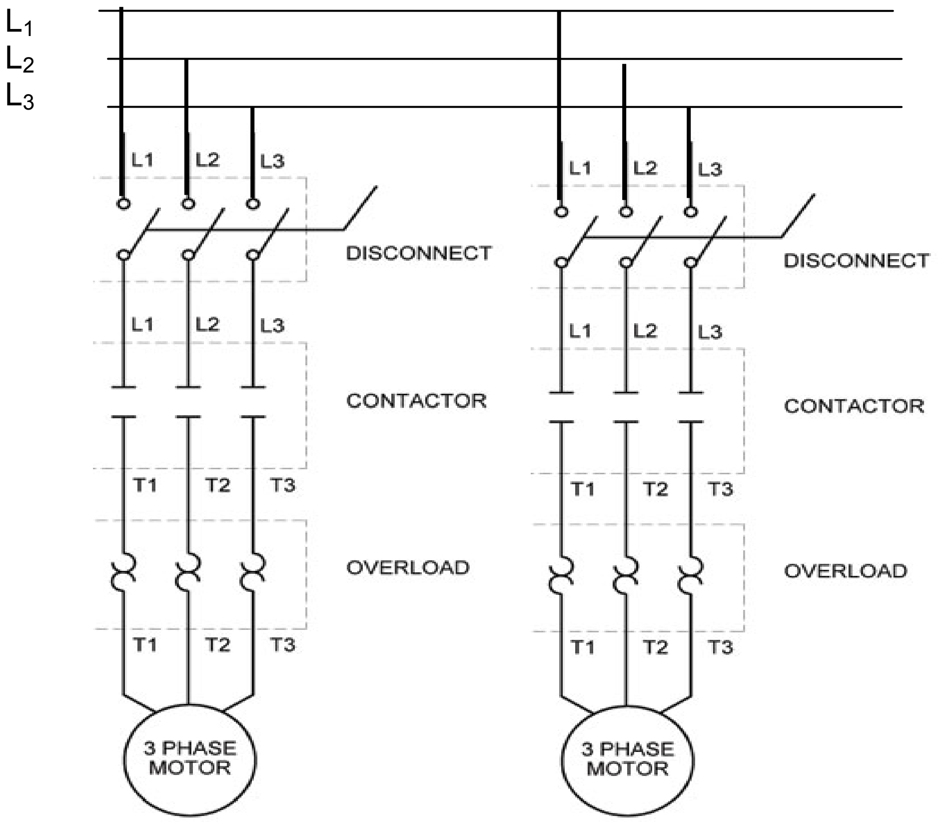
PLC unit with inputs and outputs

X1 = Stop
X2=Start
X3=O/L 1
X4 = O/L 2



Lamp 1 = Circuit is ON
Lamp 2 = Motor 1
Lamp 3 = Motor 2

Power circuit



Motor 1 Motor 2

RESOURCES:

TOOLS/INSTRUMENTS	MATERIALS
2 x three-phase contactors with auxiliary contacts 2 x three-phase overload relays 1 x stop button 1 x start button 2 x three-phase induction motors Multimeter/Clamp meter or continuity tester PLC unit Computer/Programmer Wire-striper Long nose pliers Screw driver Side cutters	Connecting wires 3 x pilot lights (red and green)

PROCEDURE:

- Convert the control circuit of a sequence motor control starter with overload and timer into a ladder logic diagram.
- Connect the PLC to control the motor.
- Run the PLC program and simulate the operation.
- Program the ladder logic diagram through a computer and load the program to the PLC.
- 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 starts rotating. After 10 seconds motor 2 also starts rotating. Both motors must be stopped by a stop button, if they trip from overload. Load the program from the computer to the PLC. Connect the PLC to control the motors.
The teacher should create faults on the PLC program for the participants to identify.

ACTIVITY

1.1 Snapshot the programmed ladder logic diagram and paste it on the blank page.

(4)

1.2 Explain why the overload relay is connected to each motor. (2)

Facet: Three-phase sequence motor control starter with overload and timer using PLC

FACETS	FACET 1	FACET 2	FACET 3	FACET 4	MAXIMUM POSSIBLE MARKS	LEARNERS 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	
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	
PLC unit	Programming the ladder logic diagram in the computer and is running	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	
Wiring of Power circuit	Testing the functionality of the motor	Correct procedure in wiring the circuit	Testing continuity in the circuit		6	
Safety				Safety precautions were observed	2	
House keeping				Housekeeping was practised	2	
					(34)	
				Activity	**(6)**	
				Facet	**(34)**	
				Total	**40**	

4.6 Simulation 6: The field-effect transistor

Specialisation:	*Power Systems* ☒	*Electronics* ☑	*Digital* ☒

Name of learner: ________________________________

Class: ___________ **Date Completed:** ______________ **MARK** ______ / 40

Date Assessed: ________________ Assessor Signature: __________________

Date Moderated: _______________ Moderator Signature: _______________________

PURPOSE:

Construct simple circuits using JFETs and MOSFETs and display the input/output waveforms on an oscilloscope

ACTIVITY 6A: Construct a circuit using a JFET as a switch

REQUIRED:

TOOLS/INSTRUMENTS	CONSUMABLES
Analogue/Digital trainer Multimeter x 2 Variable DC power supply Side cutter Wire stripper	1 x 6 V buzzer 1 x J176 JFET P channel (Any suitable JFET may be used) Connecting wires

PROCEDURE:

1. Connect the circuit on the breadboard, as shown in FIGURE 6.1.

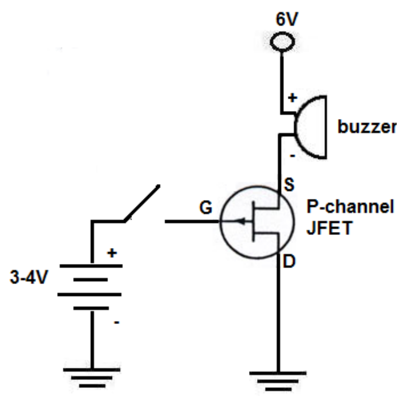


FIGURE 6.1: JFET switch

2. Close the switch and observe the output of the buzzer. Record your observation (2)

3. Open the switch and observe the output of the buzzer. Record your observation. (2)

4. **CONCLUSION:**

Explain what can be deduced from your observation with regard to a JFET as a switch. (2)

SUBTOTAL – ACTIVITY 6A: 6

FACET SHEET 6A: Construct a circuit using a JFET as a switch

	FACET 1	FACET 2	FACET 3	FACET 4	MAXIMUM POSSIBLE MARKS	LEARNER MARK
Prepare for the simulation	Identifies components correctly	Collect PSU/MiniTrainer	Collect instruments – oscilloscope	Collect hand tools	4/2 = 1	
Hand tools	Uses side cutters correctly	Use wire stripper correctly			2/2 = 1	
Preparation for insertion of components on breadboard.	Check the datasheet on the FET (1)	Set supply voltage correct at 6 V (1)	Set input voltage correct at 3–4 V (1)		3	
Correct connection on Breadboard – nodes and polarity	6 nodes for correct connection (6/2 = 3)	Polarity of buzzer – correct (1)	Polarity of JFET correct (2)		6/2 = 3	
Circuit is working correctly	Switch = ON Buzzer is OFF (1)	Switch = OFF Buzzer is ON (1)			2	
Connection of meters	Connection of MM across input to show 3 V/On/Off	Connection of MM across output = High/Low			2	
Housekeeping	Cleaning the work area after the experiment (1)	Return tools to correct places after work (1)	Disposing off waste materials correctly after work		2/2 = 1	
Safety	Observing safety before being reminded (2)	Observing safety after being reminded (1)	Not observing safety (0)		2/2 = 1	
TOTAL					**14**	

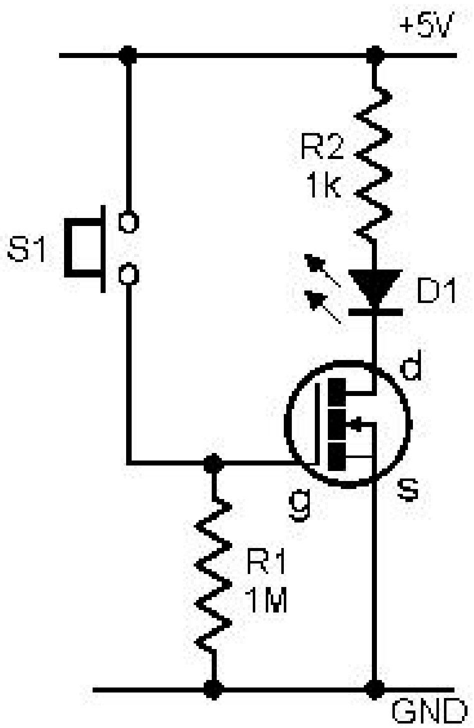
ACTIVITY 6B: Connect a circuit using a MOSFET as a switch

REQUIRED:

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer Analogue/Digital oscilloscope Function generator Variable DC power supply Side cutters Wire stripper	1 x 1 KΩ resistor 1 x MΩ resistor 1 x BS 270 N channel 1 x LED 1 x toggle switch Connecting wires

PROCEDURE:

1. Construct the circuit as shown in the circuit below.



2. Close the switch and observe the output of the LED. Record your findings (1)

3. Open the switch and observe the output of the LED. Record your findings (1)

4. Distinguish between a *depletion mode MOSFET* and an *enhancement mode MOSFET.* (2)

5. **CONCLUSION:**

Explain what can be deduced from your observation with regard to a MOSFET as a switch (1)

SUBTOTAL: ACTIVITY 6B: 5

FACET SHEET 6B: Connect a circuit using a MOSFET as a switch

	FACET 1	FACET 2	FACET 3	FACET 4	MAXIMUM POSSIBLE MARKS	LEARNER MARK
Prepare for the simulation	Identifies components correctly (1)	Collects PSU/ MiniTrainer (1)	Collects instruments – oscilloscope (1)	Collects hand tools (1)	4/2 = 2	
Hand tools	Uses side cutters correctly (1)	Uses wire stripper correctly (1)			2/2 = 1	
Preparation for insertion of components into Breadboard.	Check the datasheet on the FET (2)	Set supply voltage correctly at 6 V (1)	Set input voltage correct at 3–4 V (1)		4/2 =2	
Correct connection on breadboard – nodes and polarity	6 nodes for correct connection (6/2 = 3)	Polarity of buzzer – correct (1)	Polarity of JFET correct. (2)		6/2 = 3	
Circuit is working correctly	Switch = ON LED is ON (1)	Switch = OFF LED is OFF (1)			2	
Connection of meters	Correct setting of the multimeter (1)	Correct connection of the multimeter in terms of polarity (1)	Correct reading of the multimeter (1)		3	
Housekeeping	Cleaning the working station on completion of the experiment (1)	Returns tools after working with them (1)			2/2 = 1	
Safety	Observing safety before being reminded (2)	Observing safety after being reminded (1)	Not observing safety (0)		2/2 = 1	
TOTAL					**15**	

SUBTOTAL: ACTIVITY 6A	(6)
SUBTOTAL: FACET SHEET 6A	(14)
SUBTOTAL: ACTIVITY 6B	(5)
SUBTOTAL: FACET SHEET 6B	(15)
TOTAL : SIMULATION 6	**[40]**

4.7 Simulation 7: Amplifiers using a JFET and a Darlington pair

Specialisation:	*Power Systems* ☒	*Electronics* ☑	*Digital* ☒

Name of learner: ______________________________

Class: __________ **Date Completed:** ____________ **MARK** ____ 40

Date Assessed: ______________ Assessor Signature: ________________

Date Moderated: ______________ Moderator Signature: ____________________

PURPOSE:

Construct a simple amplifying circuit using JFETs and a Darlington pair. Display the input/output waveforms on an oscilloscope.

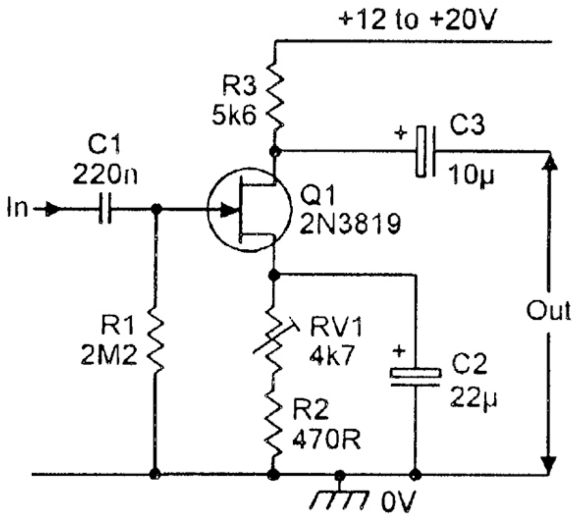
ACTIVITY 7A: Using a JFET as an amplifier

REQUIRED::

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer Analogue/Digital oscilloscope Function generator Variable DC power supply Side cutters Wire stripper	1 x 2M2 Ω resistor 1 x 5k6 Ω resistor 1 x 4k7 Ω preset resistor 1 x 470 Ω resistor 1 x 220 nF capacitor 1x 10 μF capacitor 32 V 1 x 22 μF capacitor 32 V 1 x 2N3819 JFET (2N5459 or 2N5457) Connecting wires

PROCEDURE:

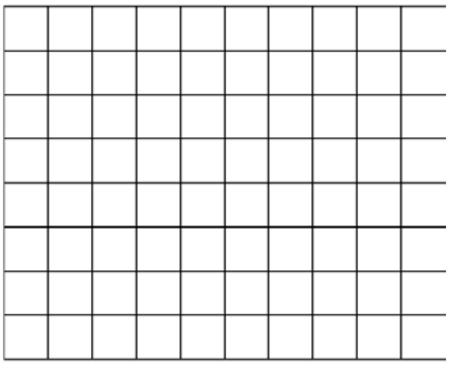
1. Build the circuit diagram on a breadboard.



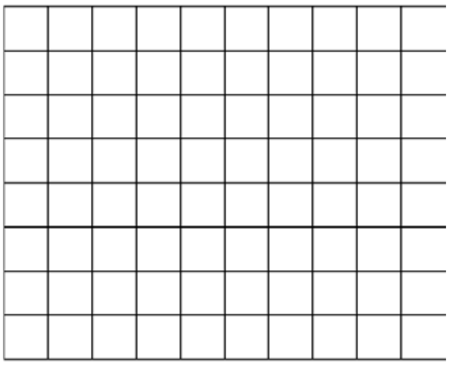
2. Connect the function generator to the input and adjust the voltage to 1 V peak

3. Connect channel 1 of the oscilloscope across the input of the amplifier and draw the waveform on the grid provided to scale. (2)

4. Connect channel 2 of the oscilloscope across the output of the amplifier and draw the wave form in the grid provided to scale. (2)



_____V/Div ________μs/Div



_____V/Div ________μs/Div

Compare the two wave forms and make your conclusion regarding the circuit. (1)

SUBTOTAL: ACTIVITY 7A: (5)

FACET SHEET 7A: Using a JFET as an amplifier

	FACET 1	FACET 2	FACET 3	FACET 4	MAXIMUM POSSIBLE MARKS	LEARNER MARK
Prepare for the simulation	Identifies components correctly	Collects PSU/ MiniTrainer	Collects instruments – oscilloscope	Collects hand tools	2/2 = 1	
Hand tools	Uses side cutters correctly	Uses wire stripper correctly			2/2 = 1	
Preparation for insertion of components on breadboard.	Checks the datasheet on the FET (1)	Sets supply voltage correctly at +12 V to +20 V (1)	Set input voltage correctly at 1 V from function generator (1)		3	
Correct connection on breadboard – nodes and polarity	6 nodes for correct connection (6/2 = 3)	Polarity of JFET correct (1)	Polarity of C2 – correct (1)	Polarity of C3 – correct (1)	6/2 = 3	
Connection of instruments	Correct setting of the oscilloscope (2)	Correct connection and reading of the oscilloscope (2)	Correct reading of the oscilloscope (2)		6/2 = 3	
Circuit is working correctly	Output amplified (1)	Output phase vs. input phase (1)			2	
Housekeeping	Cleaning the working area after the experiment (1)	Returns tools after the work (1)			2/2 = 1	
Safety	Observing safety before being reminded (2)	Observing safety after being reminded (1)			2/2 = 1	
TOTAL					**15**	

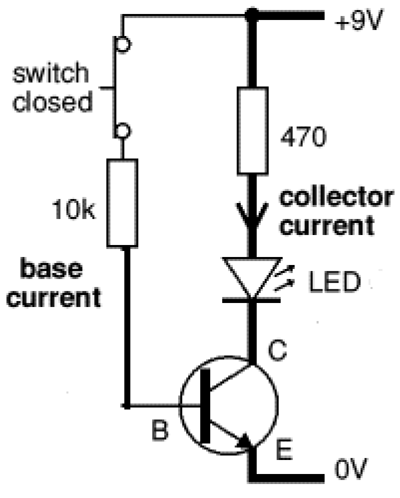
ACTIVITY 7B: Using a Darlington transistor as a current amplifier

REQUIRED:

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer Analogue/Digital function generator Variable DC power supply Side cutters Wire stripper	2 x BC 109 NPN transistors 1 x LED 1 x 470 Ω resistor 1 x 100 resistor 1 x Darlington transistor (TIP120 or TIP125) Connecting wires

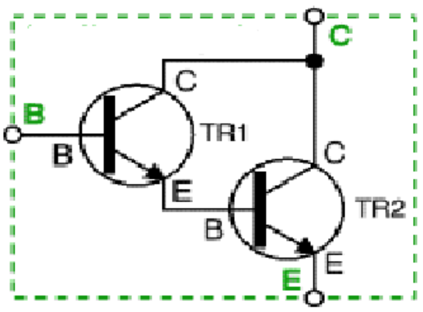
PROCEDURE:

Construct the circuit as shown in the diagram below.



Once the switch is closed observe the brightness of the LED.

Replace the single transistor with two identical BC109 transistors, as indicated below,



Once the switch is closed observe the brightness of the LED. What can you conclude from your finding? (2)

Compare the brightness when one transistor was used and when two transistors were used. (2)

Replace the two transistors with a single Darlington transistor (TIP 120 or 125) and observe the brightness of the LED. Make your own conclusion with regard the observation. (2)

[6]

FACET SHEET 7B: Using a Darlington transistor as a current amplifier

	FACET 1	FACET 2	FACET 3	FACET 4	MAXIMUM POSSIBLE MARKS	LEARNER MARK
Prepare for the simulation	Identifies components correctly (1)	Collects PSU/ MiniTrainer (1)	Collects instruments – multimeter	Collects hand tools (1)	4/2 = 2	
Hand tools	Uses side cutters correctly	Uses wire stripper correctly			2/2 = 1	
Preparation for insertion of components on breadboard	Checks the datasheet on the transistor and the Darlington pair (1)	Sets supply voltage correctly at +9 V (1)			2	
Correct connection on breadboard – nodes and polarity	6 nodes for correct connection (6/2 = 3)	Polarity of TR1 and TR2 correct (2)	Polarity of Darlington pair – Correct (2)	Polarity of LED – correct (1)	8/2 = 4	
Circuit is working correctly	When 1 transistor is connected Brightness of LED – normal (1)	When 2 transistors are connected. Brightness of LED - bright (1)	When Darlington pair is connected. Brightness of LED – bright (1)		3	
Housekeeping	Cleans the working area after the experiment (1)	Returns tools after working (1)			2/2 = 1	
Safety	Observes safety before being reminded (2)	Observes safety after being reminded (1)			2/2 = 1	
TOTAL					**14**	

SUBTOTAL: ACTIVITY 7A: (5)
SUBTOTAL: FACET SHEET 7A: (15)
SUBTOTAL: ACTIVITY 7B: (6)
SUBTOTAL: FACET SHEET 7B: (14)
TOTAL: SIMULATION 7: **40**

4.8 Simulation 8: Two stage RC amplifier and an RC phase-shift oscillator

Specialisation:	*Power Systems* ☒	*Electronics* ☑	*Digital* ☒

Name of learner: ______________________________ **MARK** ______ / 40

Class: ___________ **Date Completed:** ______________

Date Assessed: _______________ Assessor Signature: _________________

Date Moderated: ______________ Moderator Signature: ______________________

PURPOSE:

Construction of two-stage RC amplifier circuit using discrete components and an RC phase-shift oscillator and to display the input/output waveforms on an oscilloscope

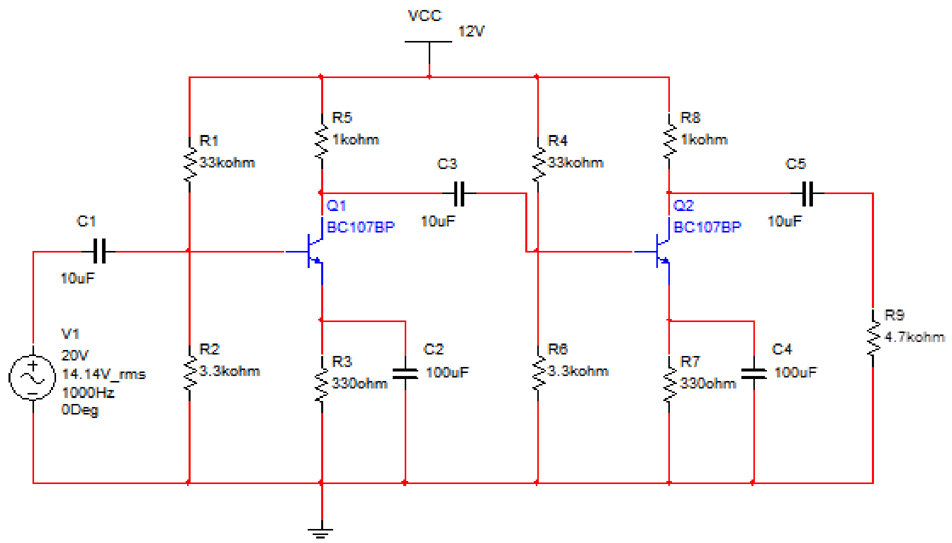
ACTIVITY 8A : Construction of two-stage RC amplifier

REQUIRED:

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer Analogue/Digital oscilloscope Function generator Multimeter Variable DC power supply Side cutters Wire stripper	2 x 4,7 kΩ resistors 2 x 1 kΩ resistors 1 x 20 µF capacitor 1 x 0,1 µF capacitor 1 x 2N4401 NPN transistor or any general-purpose NPN transistor Connecting wires Microphone

PROCEDURE:

1. Construct the circuit as shown below:



2. Connect the signal generator between the input and ground.

3. Connect channel 1 of an oscilloscope across the input of the amplifier.

4. Connect channel 2 of an oscilloscope across the output of the first stage.

5. Connect channel 2 of an oscilloscope across the output of the second stage.

Observe the output on the oscilloscope and make your own conclusion. (2)

[2]

FACET SHEET 8A: Construction of two-stage RC amplifier

	FACET 1	FACET 2	FACET 3	FACET 4	MAXIMUM POSSIBLE MARKS	LEARNER MARK
Prepare for the simulation	Identifies components correctly (1)	Collects PSU/ MiniTrainer (1)	Collects instruments – multimeter	Collects hand tools (1)	4/2 = 2	
Hand tools	Uses side cutters correctly	Uses wire stripper correctly			2/2 = 2	
Preparation for insertion of components on breadboard	Check the datasheet on the transistors (1)	Set Supply Voltage correct at +12 V (1)			2/2 = 1	
Correct connection on breadboard – nodes and polarity	6 nodes for correct connection (10/2 = 5)	Polarity of TR1 and TR2 correct (2)	Correct connection of the signal generator (1)	Correct connections of the oscilloscope (2)	10/2 = 5	
Circuit is working correctly	Channel I signal displayed on the oscilloscope (1)	Channel 2 signal displayed on the oscilloscope (1)	Output 1 signal amplified (2)	Output 2 signal amplified compared to output 1 (2)	6	
Housekeeping	Cleans the working area after the experiment (1)	Returns tools after working (1)			2/2 = 1	
Safety	Observes safety before being reminded (2)	Observes safety after being reminded (1)			2/2 = 1	
TOTAL					**18**	

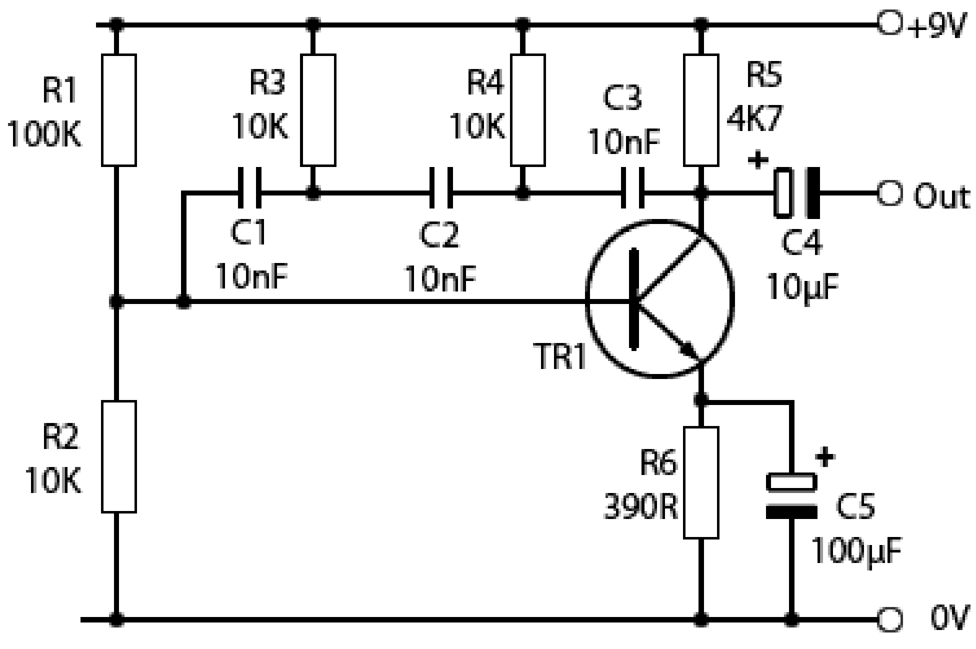
ACTIVITY 8B: Construction of an RC phase-shift oscillator using NPN transistors

REQUIRED:

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer Analogue/Digital oscilloscope Function generator Multimeter Variable DC power supply Side cutters Wire stripper	1 x 2N3904 transistor 1 x 100 µ F capacitor (electrolytic capacitor 16 V) 1 x 10 µF capacitor (electrolytic capacitor 16 V) 3 x 10 nF capacitor (non-polarised capacitors) 3 x 10 kΩ resistors 1 x 100 kΩ resistor 1 x 4,7 kΩ resistor 1 x 390 Ω resistor Connecting wires

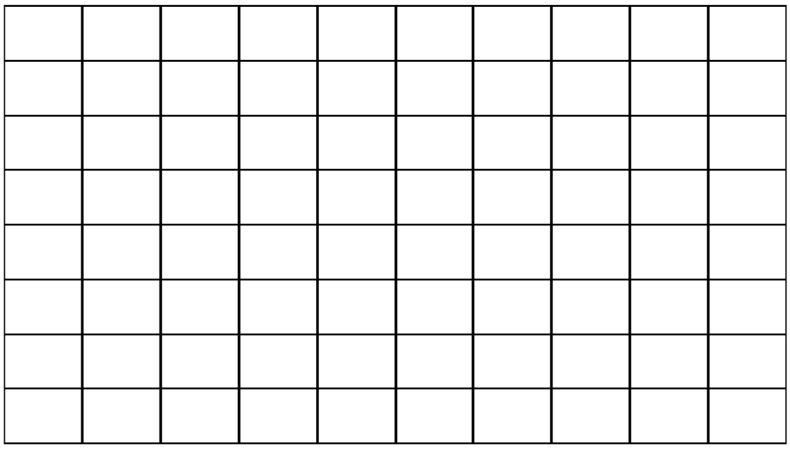
PROCEDURE:

1. Construct the circuit as shown below.



2. Connect channel 1 of an oscilloscope across the output.

3. Observe the output and draw it on the grid below. (3)



______V/Div __________μs/Div

[3]

FACET SHEET 8B: CONSTRUCTION OF RC PHASE SHIFT OSCILLATOR USING NPN TRANSISTORS

	FACET 1	FACET 2	FACET 3	FACET 4	MAXIMUM POSSIBLE MARKS	LEARNER MARK
Prepare for the simulation	Identifies components correctly (1)	Collects PSU/ MiniTrainer (1)	Collects instruments – multimeter	Collects hand tools (1)	4/2 = 2	
Hand tools	Uses side cutters correctly	Uses wire stripper correctly			2/2 = 1	
Preparation for insertion of components on breadboard	Check the datasheet on the transistors (1)	Set supply voltage correct at +9 V (1)			2	
Correct connection on breadboard – nodes and polarity	8 nodes for correct connection (8/2 = 4)	Polarity of TR, C4 and C5 correct (3)	Connections on oscilloscope correct (1)		8	
Circuit is working correctly	Channel I output displayed on the oscilloscope (1)	The output is oscillating (1)			2	
Housekeeping	Cleans the working area after the experiment (1)	Returns tools after working (1)			2/2 = 1	
Safety	Observes safety before being reminded (2)	Observes safety after being reminded (1)			2/2 = 1	
TOTAL					**17**	

SUBTOTAL ACTIVITY 8A: (2)
SUBTOTAL FACET SHEET 8A: (18)
SUBTOTAL ACTIVITY 8B: (3)
SUBTOTAL FACET SHEET 8B: (17)
TOTAL SIMULATION 8: **40**

4.9 Simulation 9: 741 op-amp and 555 IC

Specialisation:	*Power Systems* ☒	*Electronics* ☒	*Digital* ☑

Name of learner: ______________________________

Class: ____________ **Date Completed:** ______________

MARK ______ / 26

Date Assessed: ________________ Assessor Signature: ____________________

Date Moderated: _______________ Moderator Signature: _________________________

PURPOSE:

Construct a simple circuit using the 741 op-amp to build a non-inverting amplifier and display the input/output waveforms on an oscilloscope.

ACTIVITY 9A: Construct a circuit using the 741 op-amp

REQUIRED RESOURCES:

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer Analogue/Digital oscilloscope Function generator Multimeter Variable DC power supply Side cutters Wire stripper	1 x LM741 IC 1 x 1 kΩ resistor 1 x 10 kΩ resistor Connecting wires

PROCEDURE:

1. Construct the circuit on the breadboard as shown in FIGURE 9.1 below.

Learner was able to construct a minimum part of the circuit correctly without assistance	Learner was able to construct a part of the circuit correctly without assistance	Learner was able to construct the circuit correctly without assistance	
1	3	4	(4)

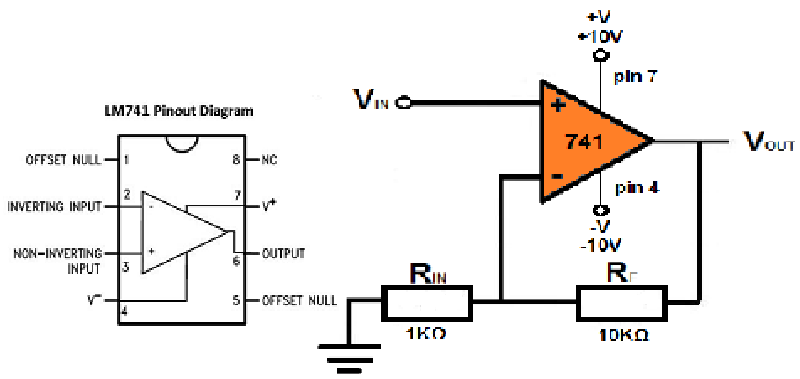


FIGURE 9.1

2. Connect the function generator between ground and Vin. (1)

3. Connect channel 1 to the input and channel 2 to the output. (2)

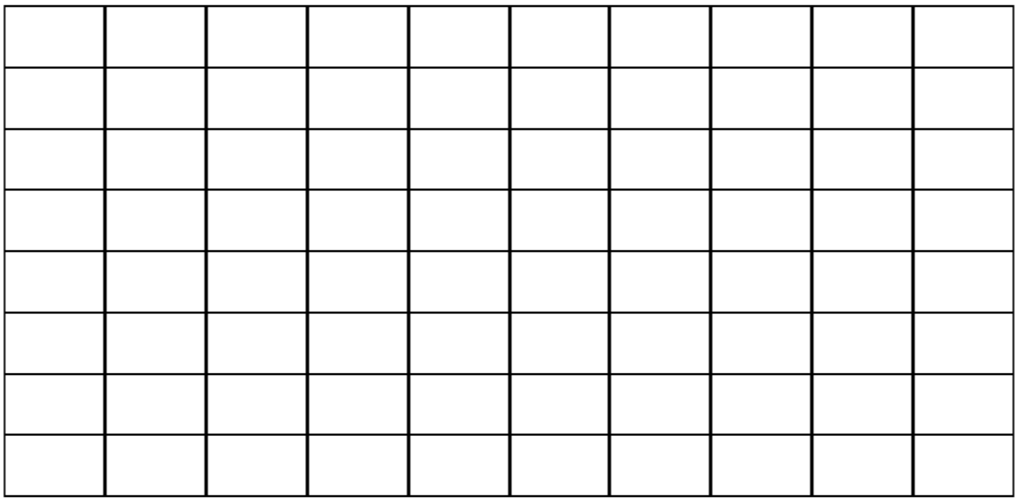
4. Set the function generator to give a sine wave output. (1)

5. Adjust the function generator to 1 000 Hz (1 kHz) at a voltage of 1 V peak. (1)

6. Switch on the power to the circuit and observe the input and output waveforms.

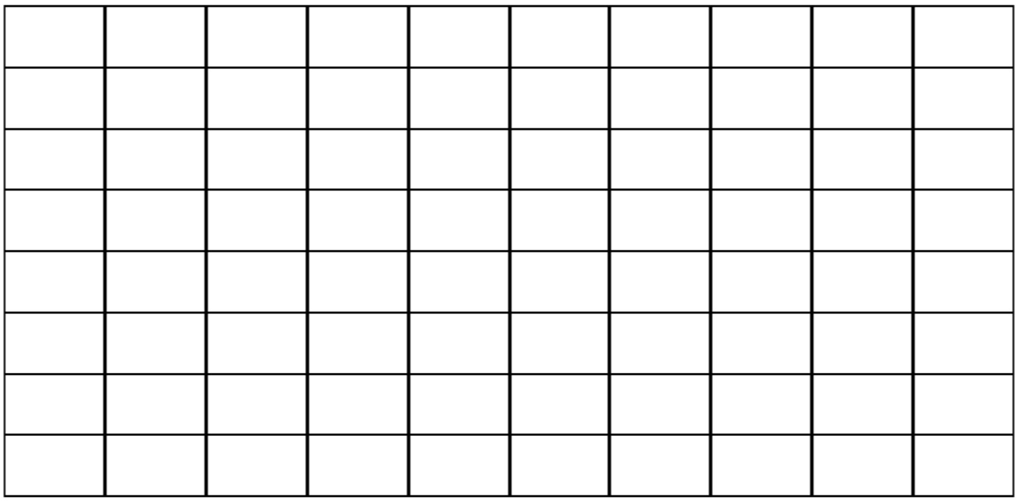
7. Draw the input and output waveforms (8)

INPUT WAVEFORM



_______V/Div ___________μs/Div

OUTPUT WAVEFORM



_______V/Div ___________μs/Div

CONCLUSION: (5)

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____

____

____

____

____

____

____

Learner did not do any housekeeping	Learner did housekeeping after being reminded	Learner did housekeeping without being reminded
1	2	3

(3)

SUBTOTAL ACTIVITY 9A: 26

ACTIVITY 9B: Construct a circuit using the 555 IC

PURPOSE:

Construct a simple circuit using the 555 IC to build a clock pulse generator (astable multivibrator) and display output waveforms on an oscilloscope

REQUIRED RESOURCES:

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer Analogue/Digital oscilloscope Function generator Multimeter Variable DC power supply Side cutters Wire stripper	1 x 555 TIMER IC 1 x 220 Ω resistor 1 x LED 1 x 10 nF capacitor 1 x 10 kΩ resistor 1 x 100 kΩ preset POT 1 x 10 µF (electrolytic capacitor 16 V) Connecting wires

PROCEDURE:

1. Construct the circuit on the breadboard as shown in FIGURE 9.2.

Learner was able to construct a minimum part of the circuit correctly without assistance	Learner was able to construct a part of the circuit correctly without assistance	Learner was able to construct the circuit correctly without assistance
1	3	4

(4)

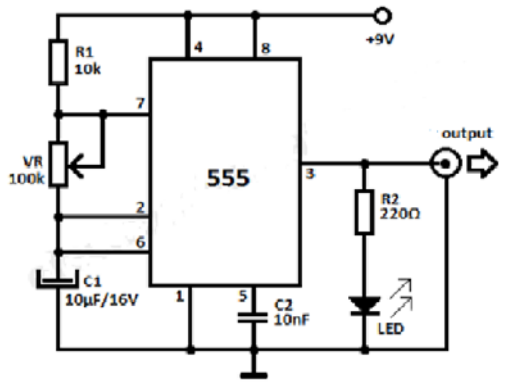


FIGURE 9.2

2. Connect channel 1 of the oscilloscope with the output

3. Switch on the power to the circuit and observe the input and output waveforms on the oscilloscope and the LED.

4. Draw the input and output wave forms observed on the oscilloscope on the grid below.

INPUT WAVEFORM

_______V/Div ___________µs/Div (1)

OUTPUT WAVEFORM

_______V/Div ___________µs/Div (2)

5. Measure the amplitude of the input and output waveforms.
Input waveform
(1)

Output waveform
(1)

B.3 What factors determine the frequency of the clock pulse?
(1)

CONCLUSION:

(2)

Learner did not do any housekeeping	Learner did housekeeping after being reminded	Learner did housekeeping without being reminded
0	1	2

(2)
[14]

SUBTOTAL ACTIVITY 9A: (26)
SUBTOTAL ACTIVITY 9B: (14)
TOTAL SIMULATION 9: 40

4.10 Simulation 10: Bi-stable Multivibrator and an LED sequencer

Specialisation:	*Power Systems* ☒	*Electronics* ☒	*Digital* ☑

Name of learner: ___________________________________

Class: ____________ **Date Completed:** _______________

MARK ____ / 18

Date Assessed: _________________ Assessor Signature: ____________________

Date Moderated: ________________ Moderator Signature: _________________________

PURPOSE:

Construct a simple circuit using the 555 IC. Build a bi-stable multivibrator and display output waveforms on an oscilloscope.

ACTIVITY 10A: Construct a circuit using the 555 IC.

REQUIRED:

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer	2 x LEDs
Analogue/Digital oscilloscope	2 X 470 Ω resistors
Function generator	1 x 10 nF capacitor
Multimeter	2 x 47 kΩ resistor
Variable DC power supply	2 x N/O tactile pushbutton switches
Side cutters	1 x 555 TIMER
Wire stripper	Connecting wires

PROCEDURE:

1. Construct the circuit on the breadboard as shown in FIGURE 10.1.

Learner was able to construct a minimum part of the circuit correctly without assistance	Learner was able to construct a part of the circuit correctly without assistance	Learner was able to construct the circuit correctly without assistance
1	3	4

(4)

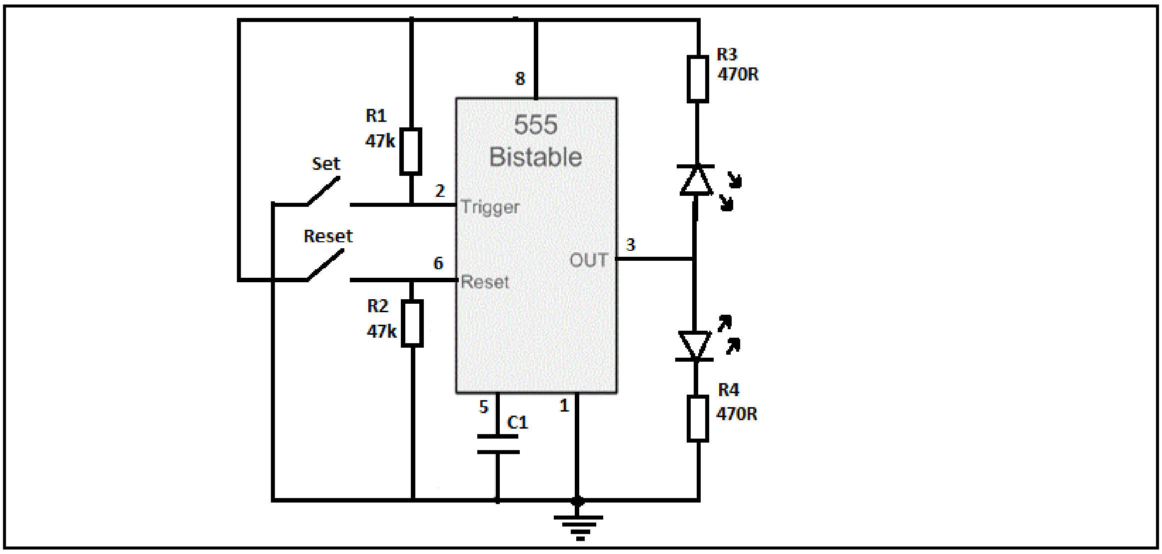


FIGURE 10.1

2. Connect channel 1 of the oscilloscope to the output. (1)

3. Switch on the power to the circuit and observe the input and output waveforms.

4. Switch on the power supply and observe the state of both LEDs:
LED1 is _______ and LED2 is ________. (2)

5. Now switch off only the SET switch and observe the state of both LEDs:
LED1 is _______ and LED2 is ________. (2)

6. Switch off only the RESET switch and observe the state of both LEDs.
LED1 is _______ and LED2 is ________.
(2)

7. Draw the input and output waveforms.

INPUT WAVEFORM (1)

OUTPUT WAVEFORM (3)

________V/DIV ________μs/DIV

8. **CONCLUSION:**

(3)

SUBTOTAL ACTIVITY 10A: 18

Simulation 10B: LED sequencer

Specialisation:	*Power Systems* ☒	*Electronics* ☒	*Digital* ☑

Name of learner: ______________________________

Class: ___________ **Date Completed:** _____________

MARK ______ / 22

Date Assessed: _______________ Assessor Signature: __________________

Date Moderated: ______________ Moderator Signature: ______________________

PURPOSE:

Construct a simple circuit using the LED Sequencer. Use a 4017B Johnson counter to light up 6 LEDs in sequence.

ACTIVITY 10B: Construct a circuit using the 4017B Johnson counter.

REQUIRED:

Caution: The 4017 IC is CMOS, and therefore sensitive to static electricity.

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer	4017 decade counter/divider
Analogue/Digital oscilloscope	555 timer IC
Function generator	Ten-segment bar graph LED
Multimeter	One SPST switch 1
Variable DC power supply	6 volt battery
Side cutters	10 kΩ resistor
Wire stripper	1 MΩ resistor, 0,1 μF capacitor
	Coupling capacitor, 0,047 to 0,001 μF
	10 x 470 Ω resistors
	Connecting wires

PROCEDURE:

1. Construct the circuit on the breadboard as shown in FIGURE 10.2 below.

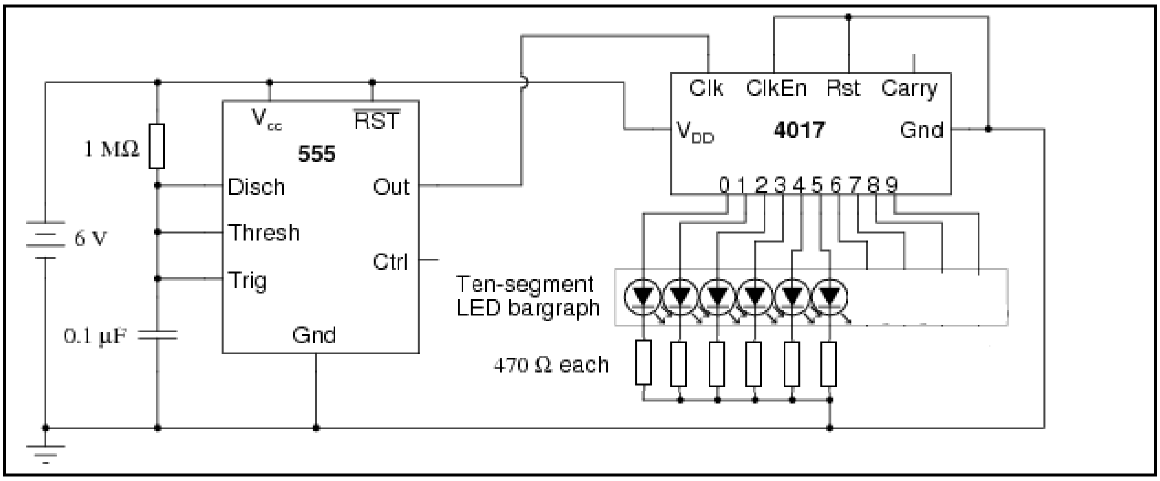


FIGURE 10.2

2. Build the 555 timer (*astable* multivibrator) circuit to produce clock pulses and observe on the oscilloscope.

Learner was able to construct a minimum part of the timing circuit correctly without assistance	Learner was able to construct a part of the timing circuit correctly without assistance	Learner was able to construct the timing circuit correctly without assistance
1	3	4

(4)

3. Draw the waveform on the grid below. (2)

INPUT WAVEFORM

_______V/Div ___________μs/Div

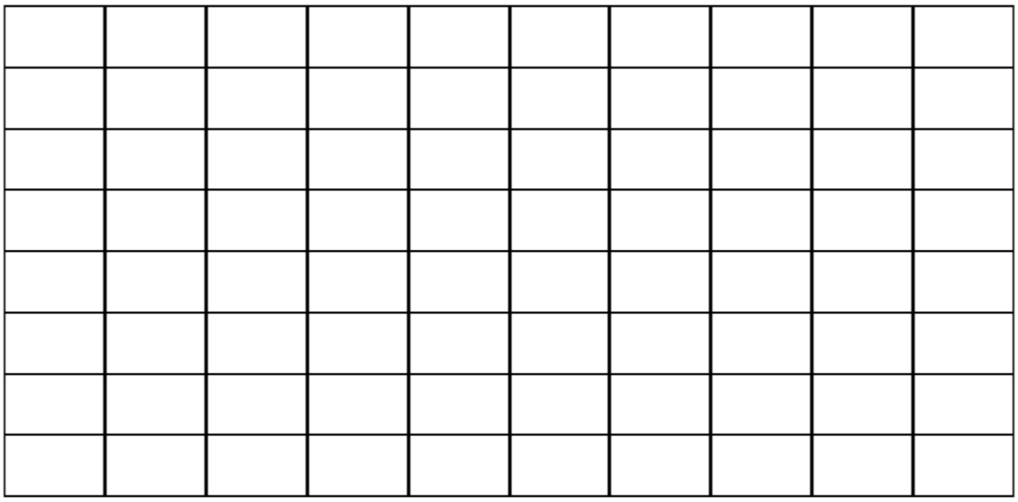
4. Build the Johnson counter and connect the output of the 555 timer to the clock pulse.

Learner was able to construct a minimum part of the counter circuit correctly without assistance	Learner was able to construct a part of the counter circuit correctly without assistance	Learner was able to construct the counter circuit correctly without assistance
1	3	5

(5)

5. Draw the output waveforms (2)

OUTPUT WAVEFORM



_______V/Div ___________μs/Div (3)

6. **CONCLUSION:**

(3)

Learner did not do any housekeeping duties	Learner did housekeeping after being reminded	Learner did housekeeping without being reminded
1	2	3

(3)
[22]

SUBTOTAL ACTIVITY 10A: (18)
SUBTOTAL ACTIVITY 10B: (22)
TOTAL SIMULATION 10: 40

4.11 Simulation 11: 741 op-amp Schmidt trigger and summing amplifier circuit

Specialisation:	*Power Systems* ☒	*Electronics* ☒	*Digital* ☑

Name of learner: ______________________________

Class: __________ **Date Completed:** ____________ **MARK** ______ / 21

Date Assessed: ______________ Assessor Signature: ________________

Date Moderated: _____________ Moderator Signature: ____________________

PURPOSE:

Construct a simple circuit using a 741 op-amp to build a Schmidt Trigger circuit and a summing amplifier circuit and display output waveforms on an oscilloscope

ACTIVITY 11A: Construct a Schmidt Trigger circuit using the 741 op-amp.

REQUIRED:

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer Analogue/Digital oscilloscope Function generator Multimeter Variable DC power supply Side cutters Wire stripper	1 x LM741 op-amp 2 x 10 kΩ resistors 3 x 1 kΩ resistor 1 x 2k2 Ω resistor (preset pot) 1 x 100 kΩ resistor 1 x 1 MΩ 1 x LED Connecting wires

PROCEDURE:

1. Construct the circuit on the breadboard as shown in FIGURE 11.1.

Learner was able to construct a minimum part of the circuit correctly without assistance	Learner was able to construct a part of the circuit correctly without assistance	Learner was able to construct the circuit correctly without assistance
1	3	4

(4)

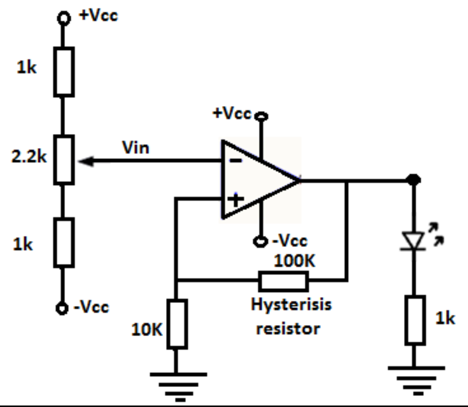


FIGURE 11.1

2. Adjust the potentiometer, while observing the output voltage.
The output switches to a HIGH when Vin is ________V
and to LOW when Vin is________V. The hysteresis is _______V. (3)

3. Replace the 100 k resistor with 10 k.
Adjust the input potentiometer slowly.

4. Watch the LED on the output. Can you change the output of the comparator to adjust the brightness of the LED? _________. (1)
The output now switches to HIGH when the input voltage is ______V (1)
and to LOW at ________V on the inset. The hysteresis is ________V. (2)

5. Replace the hysteresis resistor with 1M.
The output now switches to HIGH at _________V and to LOW at _____ V. (2)
The hysteresis is ________V. (1)
Remove the hysteresis resistor and adjust the potentiometer slowly.

6. **CONCLUSION:**

(3)

Learner did not do any housekeeping duties	Learner did housekeeping after being reminded	Learner did housekeeping without being reminded
1	2	4

(4)
[21]

Activity 11B: Construct a summing amplifier circuit using the 741 op-amp

REQUIRED:

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer Analogue/Digital oscilloscope Function generator Multimeter Variable DC power supply Side cutters Wire stripper	6 x 1 kΩ resistors 4 x 10 kΩ resistors 1 x 2k7 Ω resistor 3 x 2k2 Ω variable pots 1 x LM 741 IC Connecting wires

PROCEDURE:

1. Construct the circuit on the breadboard, as shown in FIGURE 11.2.

Learner was able to construct a minimum part of the circuit correctly without assistance	Learner was able to construct a part of the circuit correctly without assistance	Learner was able to construct the circuit correctly without assistance
2	3	5

(5)

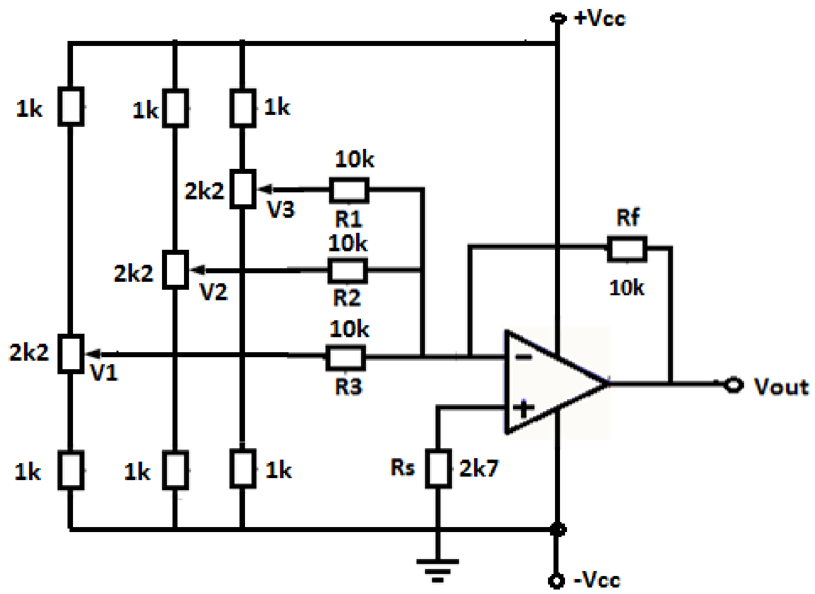


FIGURE 11.2

2. Use the 2k2Ω pots to set V1, V2 and V3 to the voltages as indicated in the table below.

3.

V_1	+	V_2	+	V_3	=	V_{out}
3	+	2.5	+	1.75	=	
1.5	+	-4	+	2.2	=	
5	+	-4.5	+	1	=	
-4	+	1.5	+	2.5	=	
-1.5	+	-2.25	+	-3.25	=	

(5)

4 **CONCLUSION:**

(5)

Learner did not do any housekeeping duties	Learner did housekeeping after being reminded	Learner did housekeeping without being reminded
1	2	4

(4)
[19]

SUBTOTAL ACTIVITY 11A: (21)
SUBTOTAL ACTIVITY 11B: (19)
TOTAL SIMULATION 11: 40

5. SECTION B: DESIGN AND MAKE

Design and Make Project

Time: January to August 2018

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):
    - No less than 7 components
    - A variety of components (both active and passive) should be used
    - Must include PCB making in some form
    - Must include soldering
    - Must include an enclosure with a switch and protection
- The checklist must be used to ensure all the required tasks for the PAT have been completed.

PAT Checklist

No.	Description	Tick (☑)	
		No	**Yes**
	Design and Make: Part 1		
1	Circuit diagram drawn	☐	☐
2	Circuit description completed	☐	☐
3	Component list completed	☐	☐
4	Tools list for circuitry populated	☐	☐
5	Measuring instrument list completed	☐	☐
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	Is 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.

5.1.2 **Project: Description of operation**
Use the space provided below to give 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 the components you will need from the circuit diagram.

LABEL	DESCRIPTION AND VALUE	QUANTITY

5.1.4 **Tools 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.

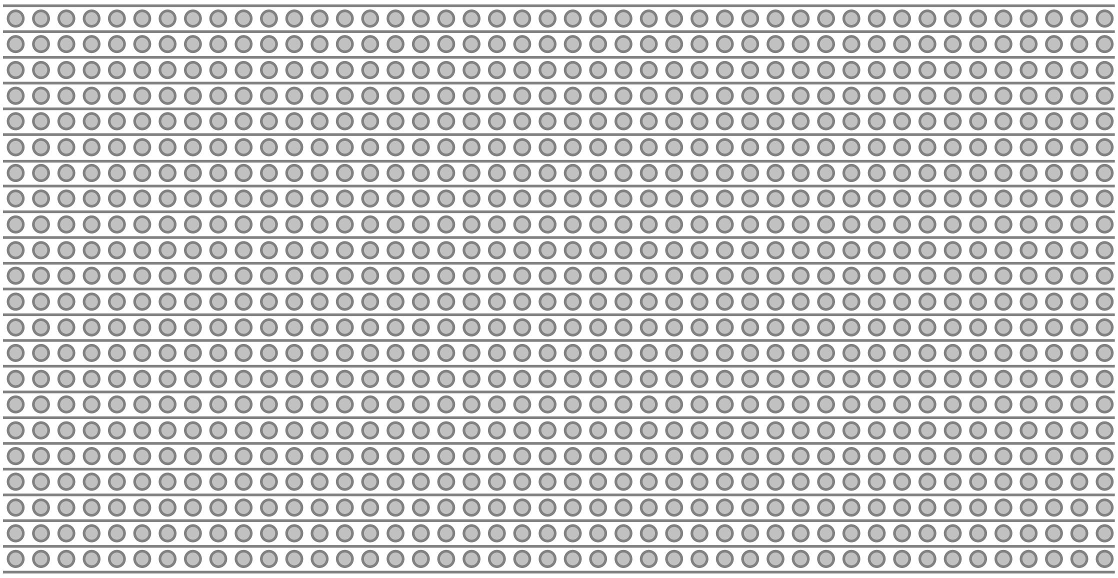
DESCRIPTION	PURPOSE/USE

5.1.5 **Evidence of prototype**
Take photographs of the working prototype on the breadboard using a digital camera or a cellphone and attach after this page. If measurements were taken, insert evidence thereof as well. Use labels to describe what is done in each photograph.

5.1.6 **Vero-board Planning/PCB Design**
Design a Vero-board OR PCB design for the circuit you are going to build. Do ONLY one of the two – NOT both! Place your design below!

Final Design – Vero-board
Same size and placement of components.

Use an **X** to show breaks made on the track



Printed Circuit Board Planning

5.2 Assessment of the design-and-make phase: Part 1

No.	Facet Description	Mark	Achieved ✓ Not Achieved ✗
Circuit Diagram			
1	Circuit diagram was drawn using EGD equipment	1	
2	Circuit diagram was drawn with EGD equipment and CAD	1	
3	Circuit diagram was drawn using correct symbols	1	
4	Circuit diagram has all labels – R1, C1, Tr1, etc.	1	
5	Circuit diagram has all component values –100 Ω, 220 µF, etc.	1	
6	Circuit diagram has a name	1	
7	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 components in the circuit diagram and component list are included in the description	1	
13	Purpose of all components in the circuit diagram and component list is described correctly.	1	
14	Learner used own interpretation and did not copy from another source verbatim	1	
15	Sources are acknowledged	1	
Tool/Instrument List			
16	The tool/instrument list has been completed	1	
17	The tools/instruments listed all have a purpose	1	
Evidence of Prototyping on Breadboard			
18	Unique original photos of the prototyping are included – Photos must not match any other learner's photos	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	
22	Video of working prototype is available as confirmation	3	
Vero-board Planning/PCB Design			
23	Board design is included in the PAT file	1	
24	Component overlay showing placement is included	1	
25	Components are labelled the same as in the circuit diagram	1	
26	Colour is used in the PCB Design	1	
27	The design is original and does not match any other learner's design	1	
28	Board layout (tracks/current flow) is functional and matches the original circuit diagram	1	

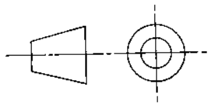
Circuit Board Manufacturing			
29	Circuit board is etched neatly according to the PCB design	5	
30	The PCB is tinned neatly (not with solder)	1	
31	The soldered PCB is covered with a clear protective coating (Plastik 70/Clear lacquer)	1	
32	Holes are drilled neatly and are aligned in the middle of the 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 is aligned between similar components (e.g. the gold bands 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 solder joints are shiny (no 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	2	
45	Wiring entering/exiting the enclosure is provided with a grommets/applicable fittings/sockets	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)	

5.2 Design and Make: Part 2

5.2.1 Enclosure design

- Design an enclosure for your project.
- NO FREEHAND DRAWINGS!
- Draw using EGD equipment or use a CAD program.
- Draw in first orthographic projection.



5.2.2 Manufacture the enclosure neatly according to your design.

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

____

5.2.4 Design a unique logo for your device below.

5.2 Assessment of the design-and-make phase: Part 2

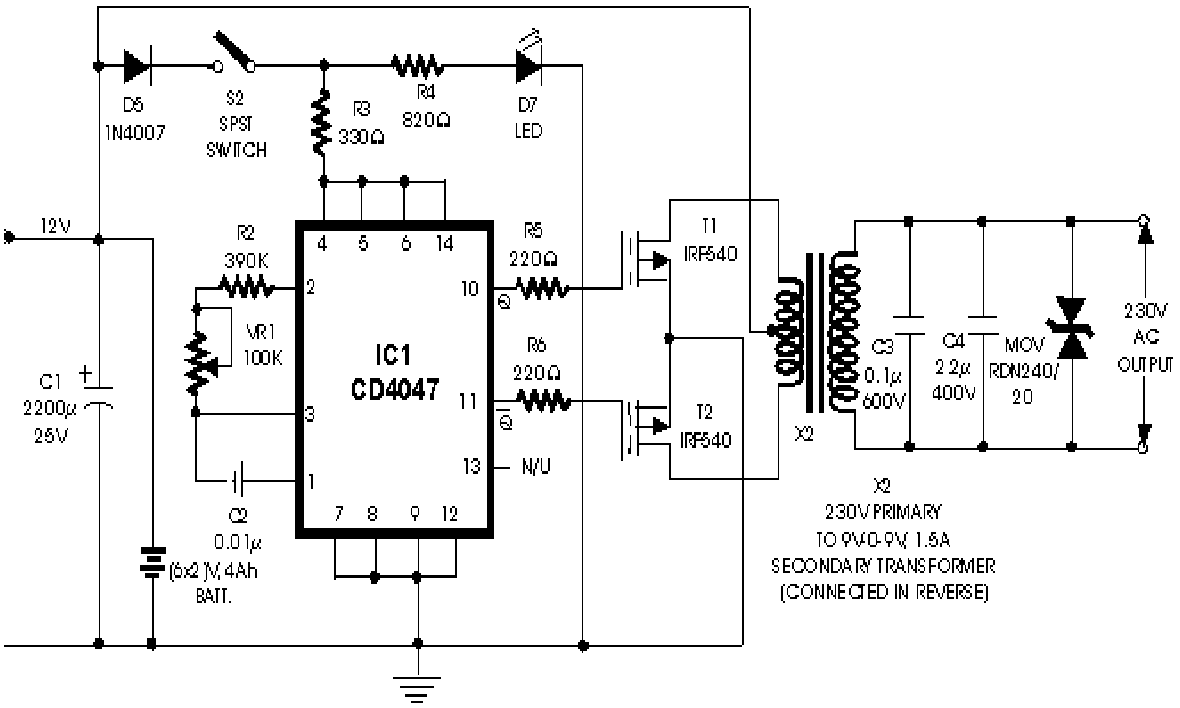
No.	Facet Description	Mark	Achieved ✓ Not Achieved ✗
Enclosure Design			
1	Enclosure design included in first-orthographic projection	1	
2	Drawn design includes a title box and page border	1	
3	Isometric drawing included additionally	1	
4	Design drawn using EGD equipment	1	
5	Design done in both CAD and EGD	1	
6	Design includes colour	1	
7	Dimensions included	1	
8	Name of the device is written on the box and in the PAT document	1	
9	The logo design is in the PAT document	1	
10	The logo design contains colour in the PAT document	1	
	Subtotal (10/2 = 5 marks maximum)		
Enclosure Manufacturing			
11	Enclosure matches the design – Dimensions and placement correlates	1	
12	Name of the device is on the enclosure	1	
13	The logo design is on the enclosure	1	
14	The logo design on the enclosure contains colour	1	
15	The logo design on the enclosure is durable and not merely a piece of paper pasted on the enclosure (painted/decoupage/ screen-printed/sublimation printed)	1	
16	The enclosure has been manufactured from scratch – **Does NOT include** injection moulded plastic boxes, cardboard boxes, paper, margarine containers and recycled enclosures) – **Does include** sheet metal, Perspex, Plexiglas, wood, glass and other raw materials)	4	
17	Holes/Cut-outs in the enclosure are made with the appropriate tools	2	
18	Specification plate with learner name, operating voltage, fuse rating and additional information on the project	1	
19	Enclosure is neatly prepared and painted and aesthetically pleasing	2	
20	The circuit board is mounted using appropriate methods inside the enclosure (NO double-sided tape, prestik, glue, chewing gum, masking tape)	1	
	Subtotal (15 marks maximum)		

TOTAL (Part 2)	

6. PROJECTS

6.1 Practical Project 1: Inverter 100 W 12 VDC to 230 V by IC 4047 – IRF540

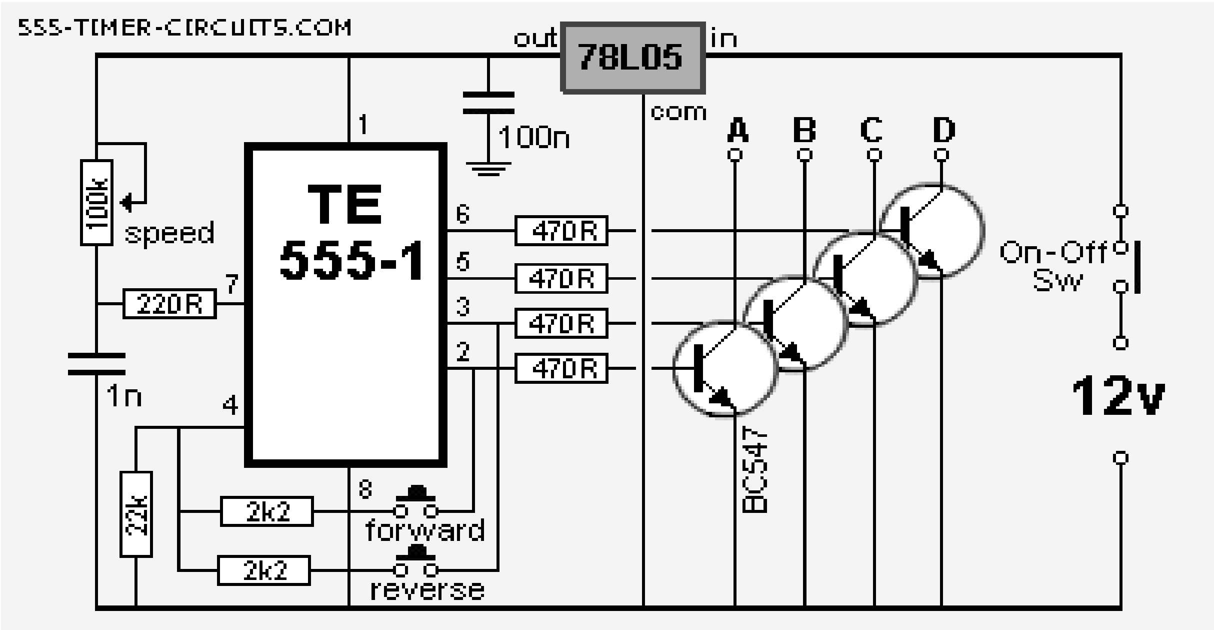
100 W inverter circuit inverts 12 VDC to 230 VAC by IC 4047 – IRF540. The circuit applied IC 4047 to generate a continuous wave signal and IRF540 to amplify the signal to be stepped up by the transformer. Take a note that you will need a 2 to 3 A centre-tapped transformer to handle/supply 100 W load.



Components list			
Diode	1N4007	VR1	100 K
C1	2200 µF	R2	□90 Ω
C2	0,01 µF	R3	330 Ω
C3	0,1 µF	R4	820 Ω
C4	2,2 µF	R5	220 Ω
		R6	220 Ω
IC 4047 – IRF540			
LED			
2 x D MOSFET (T1) IRF540			
S2 SPST switch			
Supply 12 V			
Battery 6 x 2 V (4 Ah)			

6.2 Practical Project 2: Stepper motor speed control TE 555-1

The direction of rotation is determined by the FORWARD and REVERSE switches and the motor does not take any current when a switch is not pressed.



Describe the operation of the circuit. (10)

Resistors	Capacitors	Switches	Transistors	Others
100 kΩ	1 nF	Switches	4 x BC547	Regulator LM78L05
220 Ω	100 nF	2 x push button		
22 kΩ		1 x toggle switch		IC TE 555-1
2 x 2k2 Ω				
4 x 470 Ω				

6.3 Practical project (Electronics): Traffic Light

REQUIRED:

TOOLS	MATERIALS
Oscilloscope (Analog/Digital) Analog/Digital trainer with dual power supply Electronics multimeter Side cutters Wire strippers Soldering iron Helping hands PCB etching tank or similar Solder sucker	100 kΩ resistor 220 Ω resistor x 3 22 kΩ resistor x 1 LED green x 1 LED yellow x 1 LED red x 1 1 µF capacitor x 2 10 µF capacitor x 1 470 kΩ variable resistor x 1 IC NE555 IC CD 4017 1N4007 diode x 6 PCB 150 x 100 mm Solder PCB Etching chemicals

CIRCUIT DIAGRAM: