CHAPTER 5

ELECTRICAL TECHNOLOGY

5.1   DIGITAL ELECTRONICS

The following report should be read in conjunction with the Digital Electronics question paper of the November 2021 examinations.

5.1.1   PERFORMANCE TRENDS (2018–2021)

This was the fourth time that this subject was offered as an NSC examination subject. There was a decrease of 51 candidates in this subject in 2021. The results reflect a marginal decline in the pass rate at 30% (Level 2) to 94,6% .
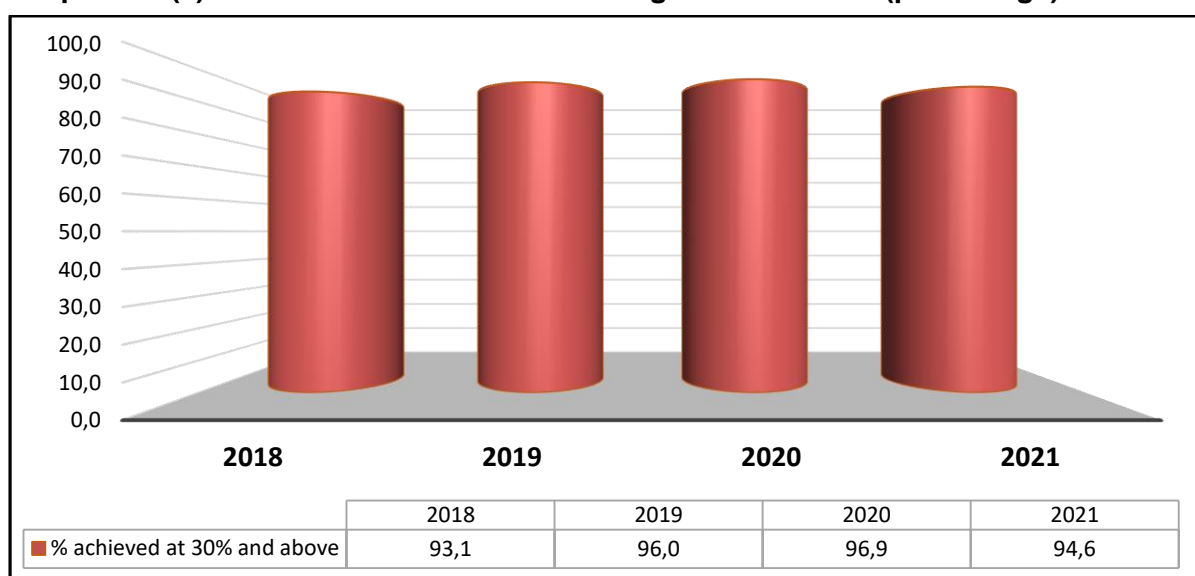
However, it was encouraging that 41,1% of candidates achieved over 50% this year in comparison to 38,8% of candidates doing so in 2020.
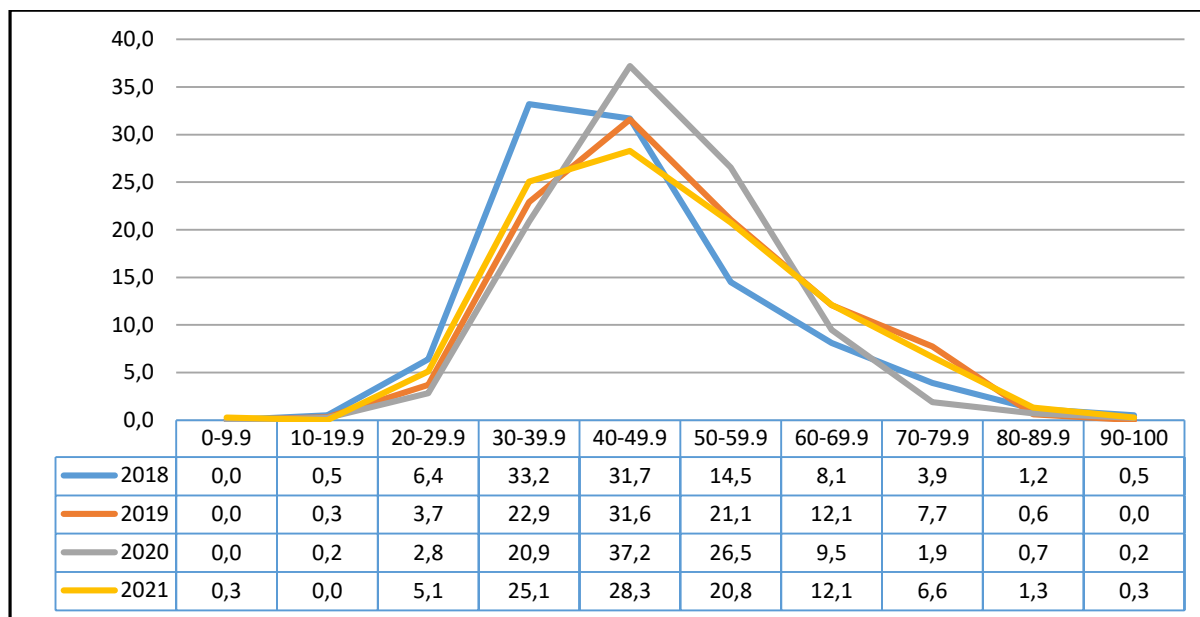
The percentage of distinctions (80%; Level 7) increased from 0,9% in 2020 to 1,6% in 2021. This translates to an increase in distinctions from 4 to 6.

Table 5.1.1 Overall achievement rates in Digital Electronics

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	407	379	93,1
2019	323	310	96,0
2020	422	409	96,9
2021	371	351	94,6

Graph 5.1.1(a) Overall achievement rates in Digital Electronics (percentage)

	2018	2019	2020	2021
■ % achieved at 30% and above	93,1	96,0	96,9	94,6

Graph 5.1.1(b) Performance distribution curves in Digital Electronics (percentage)

	0-9.9	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	70-79.9	80-89.9	90-100
2018	0,0	0,5	6,4	33,2	31,7	14,5	8,1	3,9	1,2	0,5
2019	0,0	0,3	3,7	22,9	31,6	21,1	12,1	7,7	0,6	0,0
2020	0,0	0,2	2,8	20,9	37,2	26,5	9,5	1,9	0,7	0,2
2021	0,3	0,0	5,1	25,1	28,3	20,8	12,1	6,6	1,3	0,3

General comments

Further improved performance can be achieved if there is a strengthening of content knowledge and skills in respect of the following areas: switching circuits, digital and sequential devices and microcontrollers.

In addition, learners should have practical exposure to these areas. They also need to be exposed to complex questions that use verbs, such as explain, describe, discuss, state, determine and motivate answers.

From earlier grades, learners should be exposed to problem-solving activities in all topics in the curriculum.

5.1.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE DIGITAL ELECTRONICS PAPER

General comments

(a) An overall poor performance was recorded, even in questions that were set at the lower cognitive levels.

(b) Most candidates could not interpret the requirements of the questions due to their poor language and comprehension skills.

(c) It was evident that many candidates lacked relevant content knowledge and the necessary skills to answer the questions.

(d) Many candidates experienced difficulty with answering questions of a narrative nature.

(e) The question that required learners to explain basic operations of circuits is still a challenge because of a lack of knowledge and insight on the relevant concepts.

(f) The application of mathematics, particularly manipulation and the formulation of responses after analysing circuits, requires serious attention.

(g)   Questions on the application of theory and the analysis of circuits were poorly answered. The output waveforms were not well presented and there was a decline in the correlation between the input and output waveforms.

General suggestions for improvement

(a)   Use of past NSC Papers: It must be noted that past question papers may serve as one of many teaching and learning resources if used properly. These papers may be used for learner assessment, revision purposes and, to a certain extent, teachers may use these papers for self-diagnostic assessment. Every learner must have access to past examination papers from November 2018 to November 2021 as these are based on the current *CAPS* content.

(b)   Revision of relevant Grade 10 and 11 Content: Although the NSC examinations only assess Grade 12 content, prior knowledge from the Grade 10 and 11 syllabi, serves as a foundation to equip and prepare learners to respond to Grade 12 content. It is therefore significant that this prior knowledge be incorporated in their lesson preparations/plan.

(c)   Time management: Learners must be trained in the art of managing their time and to adhere to the suggested time allocations provided in the paper. The mark allocation is a good indicator of the amount of information needed.

(d)   Practical experiments and past papers: At the end of each topic in the *CAPS* document, there are practical experiments which should be performed to enhance the understanding of the subject content. Teachers are encouraged to perform these practical tasks, which will in turn prepare learners for practical assessment tasks (PATs).

(e)   For the narrative nature of questions, the responses in the marking guidelines are broken down into key areas of specific content and marks are then awarded accordingly. A general response will only be awarded one mark. Learners must learn how to respond in the required fashion which will hone their comprehension skills and eliminate vague one-word responses. Refer to Q3.2.4, Q5.9 and Q6.5.2 where the responses are broken down in bullet form and ticks/marks are placed at key areas of specific content.

(f)   For graphical or diagrammatical nature of questions, the responses in the marking guidelines are broken down as in Q3.1.6, Q3.5.2, Q3.6.2, Q4.1.2, Q5.4, Q5.10 and Q6.8.

5.1.3 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN THE DIGITAL ELECTRONICS PAPER

QUESTION 1: MULTIPLE-CHOICE QUESTION

Common errors and misconceptions

(a)   This type of question is new. Candidates may not have had enough practice in answering them.

(b)   In Q1.1, candidates confused unsafe condition and unsafe act.

Suggestions for improvement

(a)   Learners should:
  • read carefully when answering this question;
  • not rush through the different possible answers;
  • keep in mind that only one answer is the most correct;
  • improve their content knowledge in the subject as a whole to perform well in this question;
  • be encouraged to read the textbook to gain insight; and
  • be encouraged to answer all questions because they just choose the correct answer.

(b)   Teachers are advised to include this type of question in the formal and even informal assessment tasks.

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

Common errors and misconceptions

(a)   In Q2.1 candidates confused the function of a health and safety representative with that of the safety officer. Most candidates wrote the function of a safety officer instead of a safety representative.

(b)   In Q2.2 most of the candidates answered this question by listing general human rights, but did not relate it to the workplace, hence they did not answer the question correctly.

(c)   In Q2.3 candidates could not differentiate between *unsafe acts* and *unsafe conditions*, as many wrote the definition of both.

(d)   In Q2.4 candidates confused the types of risk analysis with those of categories of risk analysis.

(e)   In Q2.5 many candidates explained *danger* in the same way as an *unsafe action or condition*.

Suggestions for improvement

(a)   It is clear that poor comprehension of the questions was a challenge. Teachers are advised and encouraged to develop activities that require definitions according to the OHS ACT and explanations of concepts and terminologies.

(a)   Teachers require content and didactic training on OHS act.

(b)   Teachers should plan, teach, and assess this topic taking *CAPS* into account at all times. This focuses learner responses on the proper direction and eliminates vague one-word responses.

(c)   The understanding of concepts and terminologies and how to describe and express them is a huge challenge to the majority of learners. The language barrier seems to be getting worse instead of improving. Learners must be encouraged to read technical literature (journals, technical books and other relevant guides) to familiarise themselves with the language and the syntax (the order or arrangement of words and phrases to form proper sentences) associated with it.

(d)   OHS needs emphasis from Grades 10 and 11, and should be incorporated in practical tasks and infused in teaching rather than being taught in isolation.

(e)   Teachers should identify their shortcomings by answering previous question papers. Their performance will inform them on the questions/sections they have challenges with and those that they are good at. Based on their performance, they could seek assistance to develop themselves.

QUESTION 3: SWITCHING CIRCUITS

Common errors and misconceptions

(a)   In Q3.1.1 most candidates did not know the function of the pull-up resistor R_1 as used in the circuit. They wrote that the function of a resistor is to limit the current instead of 'to pull up and keep pin 2 high'.

(b)   In Q3.1.2 most candidates did not know the operation of this circuit, so they could not determine the voltage across pin 2 when switch S was pressed. It had to be learnt or understood so that they could explain it in a logical fashion. Responses were vague and many did not attempt this question. Most candidates wrote 9 V instead of 0 V.

(c)   In Q3.1.3 candidates seemed to guess the states of the LED when Switch S is pressed.

(d)   In Q3.1.4 the majority of candidates did not know the correct threshold voltage in this circuit. They wrote 9 V instead of 6 V or 2/3 Vcc.

(e)   In Q3.1.5 the concept of *switch bounce* and how the circuit responds to it were not known.

(f)   In Q3.1.6 most of candidates drew the wrong output waveform. They did not know how to draw on an answer sheet provided. Other candidates did not draw at all.

(g)   In Q3.2.1 many candidates identified the multivibrator circuit incorrectly.

(h)   In Q3.2.2 the function of the resistor R_2 used in the circuit was not known by many candidates.

(i)   In Q3.2.4 the operation of this circuit was not known. Many wrote vague responses. Very few candidates answered this question

(j)   In Q3.3.1 the trigger values could not be identified by many candidates. The majority wrote +1 V/-1 V instead of +1 V to -1 V.

(k)   In Q3.3.4 the two functions of the circuit were not known by many candidates.

(l)   In Q3.4.1 candidates lost marks due to the fact that they did not label the circuit correctly and they left out the ground connector in the circuit.

(m)   In Q3.5.1 the operation of this circuit was not mastered therefor the learner responses were poor. The majority of candidates wrote resistors instead of R_1, or R_2 as labelled on the circuit diagram.

(n)   In Q3.5.2 most candidates did not draw the circuit diagram.

(o)   Where an answer sheet was provided for a question, candidates did not know how to draw on it.

Suggestions for improvement

(a)   It is important for teachers to understand that components in a circuit may perform different functions.

(b)   In Q3.1 teachers must:
- Study and understand the:
  o Internal construction of the 555 IC timer, particularly in Q3.1.4, where the concept of the three resistors is used as a voltage divider.
  o Voltage across Pin 2 when:
    ▪ Switch S is closed
    ▪ Switch S is open
- Understand why R_1 is used as a pull-up resistor, and furthermore, the purpose of R_2 and R_3 in the same circuit.
- Understand how a capacitor charges and discharges, and how these capacitors are used in this circuit, particularly C_1 and C_2. (This suggestion can also be used in Q3.2) This can also assist learners to draw-up the output waveform when Switch S is pressed.
- Study the effect that switch bouncing has on the charging and discharging of the capacitor.

(c)   In Q3.2 the concepts of input voltage (V_{in}) and reference voltage (V_{ref}) for the operation of inverting op-amp (and furthermore for non-inverting) should be explored when the trigger pulse is applied, particularly in Q3.2.4.
Understand what will happen during the following conditions:
- If $V_{in} < V_{ref}$, what will be the polarity of the output voltage
- If $V_{in} > V_{ref}$, what will be the polarity of the output voltage

(d)   In Q3.3 learners should understand the following concepts:
- Closed-loop and open-loop gain
- Identify an op-amp circuit with feedback and the purpose of such feedback

(e)   In Q3.6 learners should understand the difference between *RC integrated circuit* and *op-amp integrated circuit.*

(f)   The functions of each component in the above circuits should be studied, e.g. a capacitor and three resistors.

(g)   Electrical Technology is an applied subject, therefore the explanation of a circuit must be coupled with calculations and input and the correlating output waveforms, e.g. in Q3.4.

(h)   The changing of components affects the characteristics and the operation of the circuit. Learners should be taught these concepts and how to apply their knowledge in a dynamic circuit and to predict the output waveforms. This should direct the teacher's approach and style when teaching this subject.

(i)   Teachers must ensure that calculations include the correct steps according to the marking guidelines so that learners do not lose marks unnecessarily.

(j)   Teachers must make sure that when drawing circuits, they draw a fully labelled circuit diagram. Remember that learners use the teacher's work as a model and copy it.

(k)   The use of ICT should be integrated to enhance teaching and learning for simulations of circuits. This will strengthen their theoretical knowledge in the process.

(l)   Teachers should assist learners to analyse and interpret multivibrator circuits and answer the question related to the circuit diagram given on the question paper.

QUESTION 4: SEMICONDUCTOR DEVICES

Common errors and misconceptions

(a)   In Q4.1.1 most candidates wrote *741 op amp* instead of *non-inverting amplifier*.

(b)   In Q4.1.3 most candidates could not explain why operational amplifiers are known as differential amplifiers.

(c)   Candidates struggled with the internal function of the components of the 555 IC. Q4.2.1 and 4.2.3 asked for the function of the components in the 555 IC. Candidates answered by giving the general use of the components as a circuit standing on its own.

(d)   In Q4.2.5 candidates did not understand the function of the threshold pin 6 of the 555 IC. They all explain how the capacitor would charge and discharge but not one candidate explained the actual function of the threshold pin in relationship to the 555 IC.

(e)   In Q4.3 candidates struggled to answer the question. They did not understand the operating principle of differential amplifier and how the amplifier will react when the same signal is applied to the two inputs of the 741 operational amplifier. From the answers that the candidates supplied it was also evident that the candidates did not know the difference between the +Vcc and −Vcc and the + and − symbols in the   IEC symbol of the 741 operational amplifier. They would make reference to the positive input voltage and negative input voltage while it should be inverting and non-inverting inputs.

Suggestions for improvement

(a)   In Q4.2 a chart with pin description of the 555 IC including pin number, pin name and function of each pin should be designed and pasted on the classroom wall for learners to familiarise themselves with this IC.

(b)   The functions of the following components should be explained to learners:
  • The three series resistance used as voltage divider and how to arrive at 1/3 and 2/3 of the supply voltage
  • Two comparators
  • Transistor
  • RS flip-flop

(c)   In Q4.3 the four basic operations of the op-amp should be studied with reference to input waveform and output waveform voltages.

(d)   Learners should study the circuits and be able to distinguish between the different circuits, e.g. the difference between an *inverting operational amplifier* and a *non-inverting operation amplifier*.

(e)   Teachers must clearly explain the difference between the +*Vcc* and −*Vcc inputs* and the − an*d + symbols* in the triangle of the IEC symbol.

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

Common errors and misconceptions

(a)   In Q5.1 most candidates could not explain the term *common cathode* with reference to seven-segment LED display in words. Some even drew diagrams.

(b)   In Q5.2 a few candidates lost marks by drawing the circuit diagram without labelling it.

(c)   In Q5.3.1 most candidates were unable to determine the inputs and output of the logic gates circuit. Again, it is evident that the candidates do not understand the functions of a pull-up resistor.

(d)   In Q5.4 candidates could not draw the JK latch using the given answer sheet. It is evident that they did not study how to draw the circuit diagram. Although many attempted it, they lost vital marks by not labelling their diagrams correctly. A correct circuit with no labels was awarded zero marks.

(e)   The answers provided in Q5.7 were vague. Most candidates got 1 out of 2 marks because they were not specific in their responses. For example, they would answer *A full-sequence counter counts fully to 10 and a truncated counter counts to 7.* This answer does not clearly distinguish between the two types of counters.

(f)   The circuit in Q5.9 was answered well by the high-achieving candidates.

(g)   In Q5.10 the majority of candidates could not draw a labelled diagram of a four-bit serial in parallel-out shift register using D-type flip-flops.

Suggestions for improvement

(a)   Classrooms or workshops should display charts showing drawings of the following:
   * 7-segment LED display for common anode and cathode
   * 2-to-4 binary decoders with its truth table and symbol
   * Encoders as in FIGURE 4.3, with their truth tables, and these charts should also be used as a teaching aid to accommodate all learners because they are unique and they learn differently
   * Different types of counters and registers, their operations, truth tables and the symbols. Teachers should incorporate logic gates (e.g. AND, NAND, OR or NOR gates) as prior knowledge in their lesson plans/preparations. This will assist with the understanding of the operations, drawing of circuit diagrams, truth tables, timing diagrams and symbols of the:
      o Adders (half and full adders including binary parallel adder)
      o Flip-flop (SR, JK, and D flip-flop)

(b)   Teachers must apply instruction number 5 from the examination paper when marking learners' work, which states, *Sketches and diagrams must be large, neat and fully labelled for learners to earn full marks*.

(c)   Teachers must take time to ensure that the learners understand counters and are able to explain the function of counters, step by step.

(d)   Drawings should be of the same proportion as those the diagram sheets and must always be labelled. All inputs must correlate to the outputs with all information inserted.

(e)   Note that IEC symbols and American symbols cannot be used in the same diagram.

QUESTION 6: MICROCONTROLLERS

Common errors and misconceptions

(a)   In Q6.1 candidates' definitions for the microcontroller were too general and they lost marks for this.

(b)   In Q6.2 candidates described the microcontroller instead of explaining its principle of operation.

(c)   In Q6.3.2 devices that use the RS-485 were not known.

(d)   In Q6.8 many candidates left out the symbols and labels.

Suggestions for improvement

(a)   In order to enhance teaching and learning, the use of ICT should be integrated for simulations of circuits as most schools do not have microcontrollers. This will strengthen their theoretical knowledge in the process as this part of the examination requires higher-order thinking and understanding.

(b)   Teachers must use the examination guidelines and the *CAPS* closely when planning their teaching of this topic.

(c)   Learners must be taught to use the correct subject terminology when answering questions, avoid statements like *voltage flow* or *the current runs through the circuit* or *the output of the circuit travels from high to low*.

(d)   Learners must NOT use their own abbreviations and they must write in full sentences. Learners must refrain from using WhatsApp language when answering questions.

(e)   The general language proficiency of the learners is not at a Grade 12 level and thus learners struggle to communicate their thoughts on paper.

5.2   ELECTRONICS

The following report should be read in conjunction with the Electronics question paper of the November 2021 examinations.
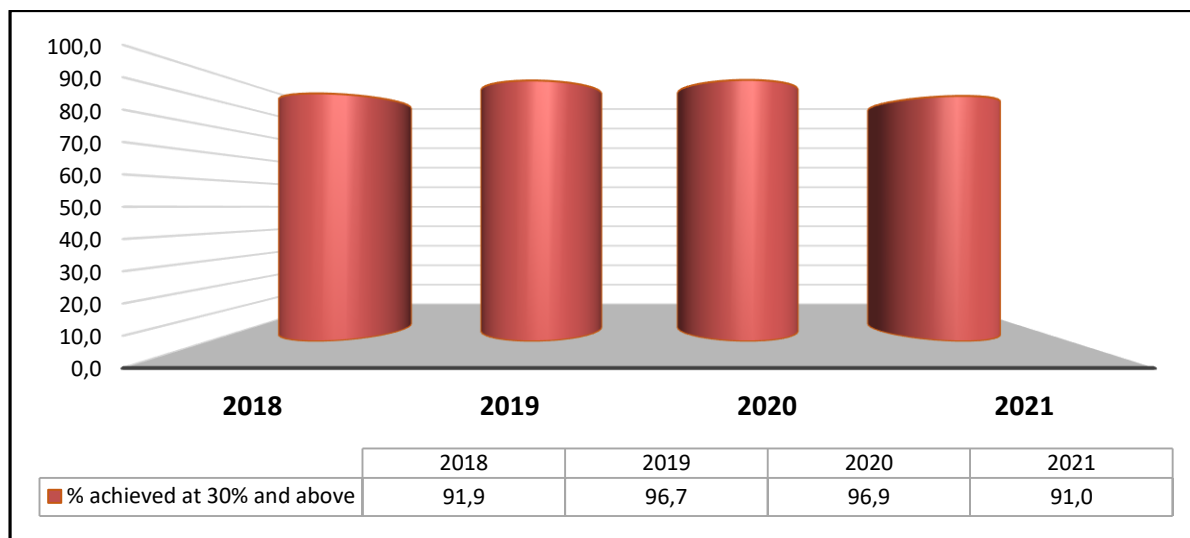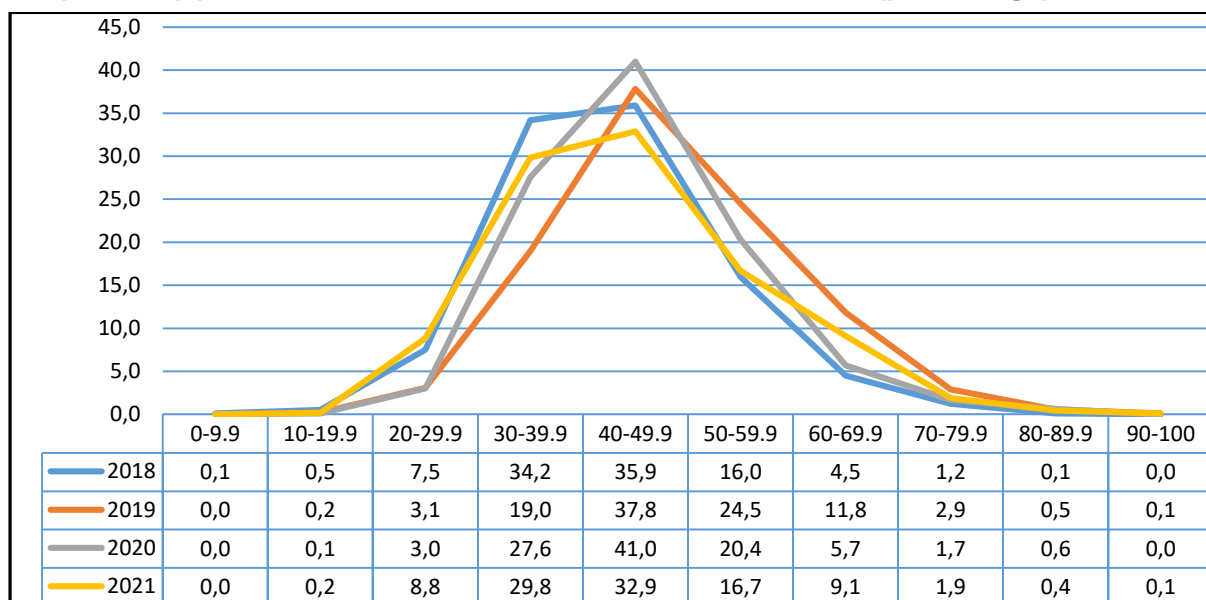
5.2.1   PERFORMANCE TRENDS (2018–2021)

This was the fourth time that this subject was offered as an NSC examination subject. In 2021, 1 143 candidates sat for the Electronics examination, i.e. an increase of 175 in comparison to the previous year.

The results reflect that the pass rate at 30% (Level 2) declined marginally from 96,9% to 91,0%. Over the past two years approximately 28% of candidates achieved over 50%. This is a decline in comparison to 38,8% of candidates doing so in 2019.

The percentage of distinctions (80%; Level 7) remained constant at approximately 0,6% This translates to total distinctions of 6 for the past two years.

Table 5.2.1 Overall achievement rates in Electronics

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	1 077	990	91,9
2019	938	907	96,7
2020	968	938	96,9
2021	1 143	1 040	91,0

Graph 5.2.1(a) Overall achievement rate in Electronics (percentage)

	2018	2019	2020	2021
% achieved at 30% and above	91,9	96,7	96,9	91,0

Graph 5.2.1(b) Performance distribution curves in Electronics (percentage)

	0-9.9	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	70-79.9	80-89.9	90-100
2018	0,1	0,5	7,5	34,2	35,9	16,0	4,5	1,2	0,1	0,0
2019	0,0	0,2	3,1	19,0	37,8	24,5	11,8	2,9	0,5	0,1
2020	0,0	0,1	3,0	27,6	41,0	20,4	5,7	1,7	0,6	0,0
2021	0,0	0,2	8,8	29,8	32,9	16,7	9,1	1,9	0,4	0,1

5.2.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE ELECTRONICS PAPER

General comments

(a)   In general, the overall performance of candidates in the paper was very poor.

(b)   Q1 (multiple-choice questions) was well answered with an average of 40% and Q2 was also well answered with an average of 50%. However, these questions comprised only 12,5% of the entire paper. Q3 was well answered with an average of 47%. This question made up 17,5% of the question paper.

(c)   Q4, Q5 and Q6 were poorly answered. These questions comprised 70% of the total of the question paper.

(d)   In general, candidates made basic mistakes, such as not selecting correct formulae, not substituting correct values in formulae, omitting the correct units and using incorrect pre-fixes of values when doing substitutions.

(e)   Candidates had difficulty answering the narrative type questions.

(f)   Language used to answer questions was also very poor. Even though the level of language used in the question paper was simple and unambiguous, candidates' responses showed that they did not understand the requirements of questions.

(g)   It was evident that many candidates lack proper content knowledge and the necessary skills to answer the questions.

(h)   Judging from the answers presented, it was evident that candidates did not read the questions carefully and proceeded to give the wrong answers. Even the low cognitive questions were not answered as expected.

(i)   Manipulation of formulae in calculations is still a challenge for many candidates. Both the application of mathematical principles and expression of responses require further attention.

(j)   Marks were lost for the omission of units in the calculations and/or for incorrect substitutions and for the omission of labels in the drawings.

(k)   The huge volume of circuit diagrams, output waveforms and characteristic curves was a challenge for most candidates.

(l)   Substitution of accurate values into the formulae is still a challenge. This contributed to candidates not calculating answers accurately.

(m)   Candidates could not draw output waveforms of the circuits.

(n)   Candidates did not know the function of components in circuits.

(o)   Candidates could not use the answer sheets provided, correctly.

(p)   There were numerous questions in the final question paper that were similar in nature to the previous question papers. However, performance was very poor and it would seem that learners did not work through previous question papers in preparation for the final question paper.

General suggestions for improvement

(a) Use of past NSC papers: It must be noted that past question papers may serve as one of many teaching and learning resources if used properly. These papers may be used for learner assessment, revision purposes, and to a certain extent, teachers may use these papers for self-diagnostic assessment. Every learner must have access to past examination papers from November 2018 to November 2021 as these are based on the current *CAPS* content.

(b) Revision of relevant Grade 10 and 11 content: Although the NSC examinations only assess Grade 12 content, prior knowledge from the Grade 10 and 11 syllabi serve as a foundation to equip and prepare learners to respond to Grade 12 content. It is therefore significant that this prior knowledge be incorporated in their lesson preparations/plan.

(c) Time management: Learners must be trained in the art of managing their time and to adhere to the suggested time allocations provided in the paper. The mark allocation is a good indicator of the amount of information needed.

(d) Practical experiments and past papers: At the end of each topic in the *CAPS* document, there are practical experiments to be performed to enhance the understanding of the subject content. Teachers are encouraged to perform these practical tasks, which will in turn prepare learners for practical assessment tasks (PATs).

(e) For questions of a narrative nature, the responses in the marking guidelines are broken down into key areas of specific content and marks are then awarded to that. A general response will get only part-marks. Learners must learn how to respond in the required fashion, which will hone their comprehension skills and eliminate one-word vague responses. Refer to Q5.2.4 and Q6.4.3 where the responses are broken down in bullet form and note the ticks/marks that are placed at key areas of specific content.

(f) For graphical or diagrammatical nature of questions, the responses in the marking guidelines are broken down as in Q4.5.2, Q5.1.6, Q5.5.2, Q5.6.2, and Q6.6 3.

(g) A deeper understanding of presenting waveforms from circuits using an EGD (Engineering Graphics and Design) approach needs much attention. Drawing waveforms on answer sheets, taking into account the correlation between input and output waveforms, is a new concept and is a vast improvement over the past Electrical Technology approach. The EGD approach prepares candidates to think like engineers. Teachers, however, still need to apply this approach in their teaching.

(h) It is of utmost importance for teachers to teach the function of components to learners. It forms part of circuit analysis and is crucial in understanding the operation of an electronic circuit.

(i) It was evident that candidates did not know the effect of altered component values and input voltages on the operation and output of circuits. Teachers must demonstrate the effect of different component values and/or input voltages on the operation and output of electronic circuits. These are higher-order concepts that must be demonstrated through practical circuits and displayed on an oscilloscope.

5.2.3 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN THE ELECTRONICS PAPER

QUESTION 1: MULTIPLE-CHOICE QUESTION

Common errors and misconceptions

(a)   This type of question is new. Candidates may not have had enough practice in them.

(b)   In Q1.1 candidates confused *unsafe condition* and *unsafe act*.

(c)   In Q1.3 candidates did not know the difference between *leading* and *lagging* when referring to phase angle.

(d)   In Q1.4 candidates did not understand the definition of *selectivity*.

Suggestions for improvement

(a)   Learners should:
   • read carefully when answering this question;
   • not rush through the different possible answers;
   • keep in mind that only one answer is the most correct;
   • improve their content knowledge in the subject as a whole to perform well in this question;
   • be encouraged to read the textbook to gain insight; and
   • be encouraged to answer all questions because they just choose the correct answer.

(b)   Teachers are advised to include this type of question in the formal and even informal assessment tasks.

(c)   The teacher should emphasise the difference between *lagging* and *leading* terminologies, including the relationship between *current* and *voltage* in an inductive, capacitive and resistive circuit.

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

Common errors and misconceptions

(a)   In Q2.1 candidates confused the function of a health and safety representative with that of the safety officer. Most candidates wrote the function of a safety officer instead of that of a safety representative.

(b)   In Q2.2 most of the candidates answered this question by listing general human rights, but did not relate it to the workplace, hence they did not answer the question correctly.

(c)   In Q2.3 candidates could not differentiate between *unsafe acts* and *unsafe conditions*, as many wrote the definition of both.

(d)   In Q2.4 candidates confused *types of risk analysis* with *categories of risk analysis*.

(e)   In Q2.5 many candidates explained *danger* in the same way as an *unsafe action* or *condition*.

Suggestions for improvement

(b)   It is clear that poor comprehension of the questions was a challenge. Teachers are advised and encouraged to develop activities that require definitions according to the OHS ACT and explanations of concepts and terminologies.

(c)   Teachers require content and didactic training on the OHS Act.

(d)   Teachers should plan, teach, and assess this topic taking *CAPS* into account at all times. This focuses learner responses in the proper direction and eliminates one-word vague responses.

(e)   The understanding of concepts and terminologies and how to describe and express them is posing a huge challenge to the majority of learners. The language barrier seems to be getting worse instead of improving. Learners must be encouraged to read technical literature (journals, technical books and other relevant guides) to familiarise themselves with the language and the syntax (the order or arrangement of words and phrases to form proper sentences) associated with it.

(e)   OHS needs emphasis from Grades 10 and 11, and should be incorporated in practical tasks and infused in teaching rather than being taught in isolation.

(f)   Teachers should identify their shortcomings by answering previous question papers. Their performance will inform them on the questions/sections they have challenges with and those that they are good at. Based on their performance, they could seek assistance to develop themselves.

QUESTION 3: RLC CIRCUITS

Common errors and misconceptions

(a)   In Q3.1 many candidates were unable to recall the definition of *capacitive reactance*. Many did not refer to AC in their attempt to answer the question.

(b)   In Q3.2 most candidates did not state the phase relationship between current and voltage in an inductive circuit.

(c)   In Q3.3.1 and Q.3.4.4 the majority of candidates could not make L and C, respectively, the subject of the formula from the formulae taken from the formula sheet. This affected the substitution and the answer. Some candidates did not use units or they used incorrect units.

(d)   In Q3.3.2 most of candidates lost marks by omitting the units in their final answers.

(e)   In Q3.3.3 many candidates included a unit in the final answer and lost a mark because power factor has no units. Some candidates used the incorrect formula and calculated the phase angle and not the power factor.

(f)   In Q3.3.4 most candidates did not know that the unity power factor is the same as the power factor is equal to 1.

(g)   In Q3.4.1 and Q3.4.2 candidates could not identify the resonant frequency from data given to them.

(h)   Q3.4.2 most candidates could not compare the values of the inductive and capacitive reactances when the frequency increases, as given from the data in FIGURE 3.4B.

(i)   Q3.4.3 many candidates did not consider the engineering notation prefix when calculating the volt drop across the inductor resulting in the loss of 2 marks.

(j)   In Q3.5.2 candidates could not calculate the voltage drop across the inductor as many used the incorrect formula.

Suggestions for improvement

(a)   Teachers should illustrate the phase relationship between I and V in a/an:
   - Resistive circuit
   - Inductive circuit
   - Capacitive circuit
   and explain why a circuit is inductive or capacitive.

(b)   Teachers should explain the effect of varying the frequency of the supply in an RLC circuit, the characteristics curve and phasor diagrams of resonance circuits and the conditions of series/parallel resonant circuits**.**

(c)   The following should be considered:
   - Lesson plans developed by teachers and not by subject advisors is key to these challenges, for example:
     o   To reflect on what worked well during the presentation, and what could have been done differently for further improvement of the next lesson plan
     o   To reflect on prior learning to introduce the content to be learned. (i.e. prior learning might be from either the previous grades or previous topics learned from the same grade)
   - Integrate relevant mathematical concepts, e.g. manipulation of formulae, as they teach calculations
   - Teach how to identify the correct formula from the formula sheet and application thereof
   - Develop an assessment task based on the following:
     o   Identification of the formula for specific calculations
     o   Manipulation of formulae
     o   Units for specific quantities, e.g. voltage, current, resistance, impedance, frequency, phase angle, bandwidth, etc.
     o   Prefixes, e.g. nano-, micro-, milli-, kilo- and the conversion thereof
     o   Use of the calculator
     o   These assessment tasks should also be implemented in section with calculations, e.g. in semiconductors and switching circuits

(d)   The definitions of the terms, explanations and descriptions of concepts that are likely to be asked in the examination should be summarised in a booklet and handed to learners at the beginning of the year.

(e)   Learners must be trained to read the question carefully and to look at the mark allocation. The number of facts provided must correlate with the number of marks.

(f)   Learners need to read questions with understanding so that they answer appropriately. Similar questions should be given during the year in preparation for the final examination.

(g)   The application and understanding of data taken from these circuits to answer theoretical style questions is a major problem currently. The practical building of RLC circuits and the checking of the waveforms on the oscilloscope is a good way of reinforcing the theory.

QUESTION 4: SEMICONDUCTOR DEVICES

Common errors and misconceptions

(a)   In Q4.2.1 candidates could not identify the symbol of the P-channel enhancement-mode metal oxide silicon field effect transistor (MOSFET).

(b)   In Q4.3.1 candidates could not identify the pulse.

(c)   In Q4.3.2 most candidates did not know the meaning of *saturation region* with reference to the operation of the UJT.

(d)   In Q4.3.3 many candidates could not describe how the UJT is driven into saturation.

(e)   In Q4.3.4 candidates could not draw the output waveform on the provided answer sheet.

(f)   In Q4.4.1 many candidates identified the circuit correctly but responses were not complete. One-word answers like *transistor* or *Darlington* were given.

(g)   In Q4.5.1 most candidates confused this circuit with the inverting amplifiers. They wrote *741 op amp* instead of *non-inverting amplifier*. They could not draw the output waveforms correctly in Q4.5.2.

(h)   In Q4.5.3 the majority of candidates did not know the concept of differential voltage amplifiers and could not explain why operational amplifiers are known as differential amplifiers.

(i)   Candidates struggled with the internal function of the components of the 555 IC. Q4.6.1 and 4.6.3 asked for the function of the components in the 555 IC and the candidates answered by giving the general use of the components as a circuit standing on its own.

(j)   In Q4.6.5 candidates did not understand the function of the threshold pin 6 of the 555 IC. They all explained how the capacitor would charge and discharge but not one candidate explained the actual function of the threshold pin in relationship to the 555 IC.

(k)   In Q4.7 candidates struggled to answer the question. They did not understand the operating principle of the differential amplifier, and how the amplifier will react when the same signal is applied to the two inputs of the 741 operational amplifier. From the answers that the candidates supplied it was also evident that the candidates did not know the difference between the $+Vcc$ and $-Vcc$ and the $+$ *and* $-$ *symbols* in the IEC symbol of the 741 operational amplifier. They would make reference to the positive input voltage and negative input voltage while it should be inverting and non-inverting inputs.

Suggestions for improvement

(a)   Teachers must spend more time teaching the construction, operation and symbols of the different MOSFETs.

(b)   When teaching the operation of components, reference must be made to the characteristic curve and the construction of the components.

(c)   The operation of the Darlington pair must be carefully explained, as well as the advantages of this combination.

(d)   Teachers must provide a detailed explanation of the operation of op-amp circuits and demonstrate it with practical circuits.

(e)   It is important to use practically built circuits with voltage measurements in conjunction with the theoretical concepts being addressed.

(f)   Teachers must emphasise the identification of formulae and link it with the correct circuits during class lessons. Teachers must also emphasise the importance of using the correct prefixes in all calculations and showing them in the substitutions. This must be applied strictly during the year in informal tasks and during the marking of all assessment tasks. Candidates lose marks if these are not in place, even if all the steps are correct.

(g)   The internal operation of the 555 IC is of utmost importance, not only in this section, but also for switching circuits. Teachers can show educational videos on the operation of the 555 IC to learners. Learners must be motivated to build practical circuits to embed theoretical knowledge. Teachers can also use educational software to enhance the learning experience of difficult abstract circuits and concepts.

QUESTION 5: SWITCHING CIRCUITS

Common errors and misconceptions

(a)   In Q5.1.1 most candidates did not know the function of the pull-up resistor R_1 as used in the circuit. They wrote that the function of a resistor is to limit the current instead of *to pull up and keep pin 2 high*.

(b)   In Q5.1.2 the majority of candidates did not know the operation of this circuit, so they could not determine the voltage across pin 2 when switch S was pressed. It had to be learnt or understood so that they could explain it in a logical fashion. Responses were vague and many did not attempt this question. The majority of the candidates wrote 9 V instead of 0 V.

(c)   In Q5.1.3 candidates seemed to guess the states of the LED when Switch S is pressed.

(d)   In Q5.1.4 the majority of candidates did not know the correct threshold voltage in this circuit. They wrote 9 V instead of 6 V or 2/3 Vcc.

(e)   In Q5.1.5 the concept of switch bounce and how the circuit responds to it were not known.

(f)   In Q5.1.6 most of candidates drew the wrong output waveform. They did not know how to draw on an answer sheet provided. Other candidates did not draw at all.

(g)   In Q5.2.1 many candidates identified the multivibrator circuit incorrectly.

(h)   In Q5.2.2 the function of the resistor R_2 as used in the circuit, was not known by many candidates t.

(i)   In Q5.2.4 the operation of this circuit was not known. Many wrote vague responses. Very few candidates answered this question

(j)   In Q5.3.1 the trigger values could not be identified by many candidates. The majority wrote +1 V/-1 V instead of +1 V to -1 V.

(k)   In Q5.3.4 the two functions of the circuit were not known by many candidates.

(l)   In Q5.4.1 candidates lost marks due to the fact that they did not label the circuit correctly and they left out the ground connector in the circuit.

(m)   In Q5.5.1 the operation of this circuit was not mastered therefore the learner responses were poor. The majority of candidates wrote resistors instead of R_1, or R_2 as labelled on the circuit diagram.

(n)   In Q5.5.2 most candidates did not draw the circuit diagram.

(o)   Where an answer sheet was provided for a question, candidates did not know how to draw on it.

Suggestions for improvement

(a)   It is important for teachers to understand that components in a circuit may perform different functions.

(b)   In respect of Q5.1 teachers must:
- Study and understand the:
  - Internal construction of the 555 IC timer, particularly in Q5.1.4, where the concept of the three resistors is used as a voltage divider
  - Voltage across Pin 2 when switch S is:
    - Closed
    - Open
- Understand why R_1 is used as a pull-up resistor, and furthermore, the purpose of R_2 and R_3 in the same circuit.
- Understand how a capacitor charges and discharges, and how these capacitors are used in this circuit, particularly C_1 and C_2. (This suggestion can also be used in Q5.2) This can also assist learners to draw-up the output waveform when Switch S is pressed.
- Study the effect that switch bouncing has on the charging and discharging of the capacitor.

(c)   In Q5.2 the concepts of input voltage (V_{in}) and reference voltage (V_{ref}) for the operation of inverting op-amp (and furthermore for non-inverting) should be explored when the trigger pulse is applied, particularly in Q5.2.4.
Understand what will happen during the following conditions:
- If $V_{in} < V_{ref}$, what will be the polarity of the output voltage
- If $V_{in} > V_{ref}$, what will be the polarity of the output voltage

(d)   In Q5.3 learners should understand the following concepts:
- Closed-loop and open-loop gain
- An op-amp circuit with feedback and the purpose of such feedback

(e)   In Q5.6 learners should understand the difference between *RC integrated circuit* and *op-amp integrated circuit.*

(f)   The functions of each component in the above circuits should be studied, e.g. a capacitor and three resistors.

(g)   Electrical Technology is an applied subject therefore the explanation of a circuit must be coupled with calculations and input and the correlating output waveforms, e.g. in Q5.4.

(h)   The changing of components affects the characteristics and the operation of the circuit. Learners should be taught these concepts and how to apply their knowledge in a dynamic circuit and to predict the output waveforms. This should direct the teacher's approach and style when teaching this subject.

(i)   Teachers must ensure that calculations include the correct steps according to the marking guidelines so that learners do not lose marks unnecessarily.

(j)   Teachers must make sure that when drawing circuits, they draw a fully labelled circuit diagram. Remember that learners use the teacher's work as the model and copy it.

(k)   The use of ICT should be integrated to enhance teaching and learning for simulations of circuits. This will strengthen their theoretical knowledge in the process.

(l)   Teachers should assist learners to analyse and interpret multivibrator circuits and answer the question related to the circuit diagram given on the question paper.

QUESTION 6: AMPLIFIERS

Common errors and misconceptions

(a)   In Q6.1.1 and Q6.1.2 candidates could not explain class AB and class C amplifiers. Candidates confused the biasing point or Q-point.

(b)   In Q6.2 most candidates were unable to define *negative feedback*.

(c)   In Q6.3.1 and Q6.3.2 most candidates could not provide the correct answer.

(d)   In Q6.3.3 most candidates were unable to draw the correct output waveform due to a lack of practical and theoretical knowledge of transistor operation. Most candidates did not show the DC offset at point B and C and did not show amplification and inversion.

(e)   In Q6.3.4 most candidates could not describe the relationship between the *collector current* and the *collector-emitter voltage* when the input signal is applied due to a lack of practical knowledge. The inverse relationship of the collector current and voltage was not known by many learners. They described it as a *linear relationship*.

(f)   In Q6.3.5 the majority of candidates could not select the correct formula.

(g)   In Q6.4.1 most candidates could not identify the components that determine oscillation frequency.

(h)   In Q6.4.2 candidates gave one-word answers like *capacitor* or *choke*.

(i)   In Q6.4.3 most candidates were unable to explain the operation of the circuit.

(j)   In Q6.4.4 most candidates selected the wrong formula which led to incorrect calculation of the oscillation frequency.

(k)   In Q6.5.2 candidates could not state the function of transformer T_1. They confused this circuit with a radio amplifier. Some called it a *transformer coupled RC amplifier*.

(l)   In Q6.5.3 most candidates could not describe why the transformer T_1 is more efficient than RC stage.

(m)   In Q6.5.4, Q6.6.3, Q6.6.4 and Q6.6.5 most of the candidates did not provide the correct answer.

(n)   In Q6.6 candidates could not:
- Identify the type of oscillator
- State the requirement for positive feedback
- State the function of the RC network
- Define the term *attenuation.*

Suggestions for improvement

(a)   All classes of amplifiers, as prescribed in the *CAPS* document, must be explained and be graphically drawn showing input and output signals through their characteristics.

(b)   The definitions and basic concepts of amplifiers must be emphasised.

(c)   Teachers must:
- Emphasise the skill of circuit analysis and interpretation in order for learners to correctly identify circuits and the function of each component
- Build amplifier circuits during practical lessons and display the input and output signals on an oscilloscope. They must also change the value of the input signal and value of components to show their effect on the output of the circuit.
- Teach characteristic curves of amplifiers with the circuit analysis and function of different components as a whole and not separately
- Make use of educational software to demonstrate abstract concepts, especially in amplifier circuits. Display the voltages across components on an oscilloscope to make this abstract concept visual.
- Build oscillator circuits during practical lessons to demonstrate and explain the operation of these types of circuits. Teachers can also use educational software to build these circuits to explain and demonstrate its operation.
- Demonstrate the function of the components by either disconnecting them or replacing them with other components to show the importance of such specific components
- Explain the use of FET and BJT transistors in oscillator circuits as well as their advantages
- Emphasise the calculation and demonstration of oscillation frequency using different component values
- Focus on this concept by using calculations, simulations and transistor characteristics (including drawing of the load line on the graph) in order for learners to develop visual understanding of this abstract concept

- Explain to learners how the biasing of a transistor and the different values of RB will determine the Q-point of the transistor on the load line
- Explain the purpose of the feedback circuit and the amplifier circuit in an oscillator, e.g. LC oscillator and RC-oscillator circuits.

(d)   Content coverage and mastery with regular informal assessment activities on theory and drawing of circuits using an Engineering Graphics and Design (EGD) approach will benefit learners' understanding.

5.3 POWER SYSTEMS

This report should be read in conjunction with the Power Systems question paper and marking guidelines of the November 2021 examinations.
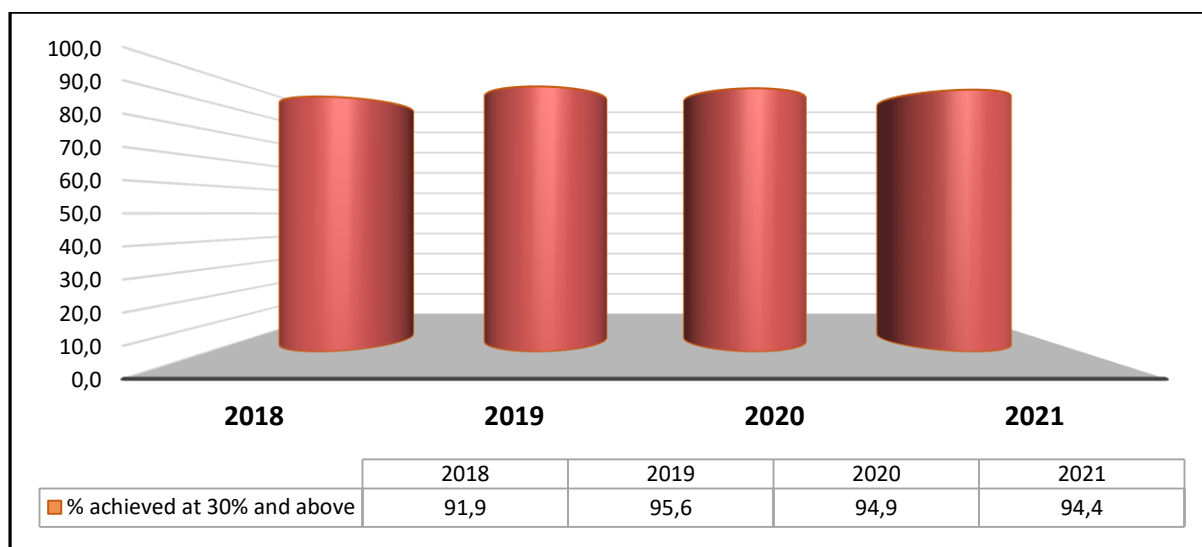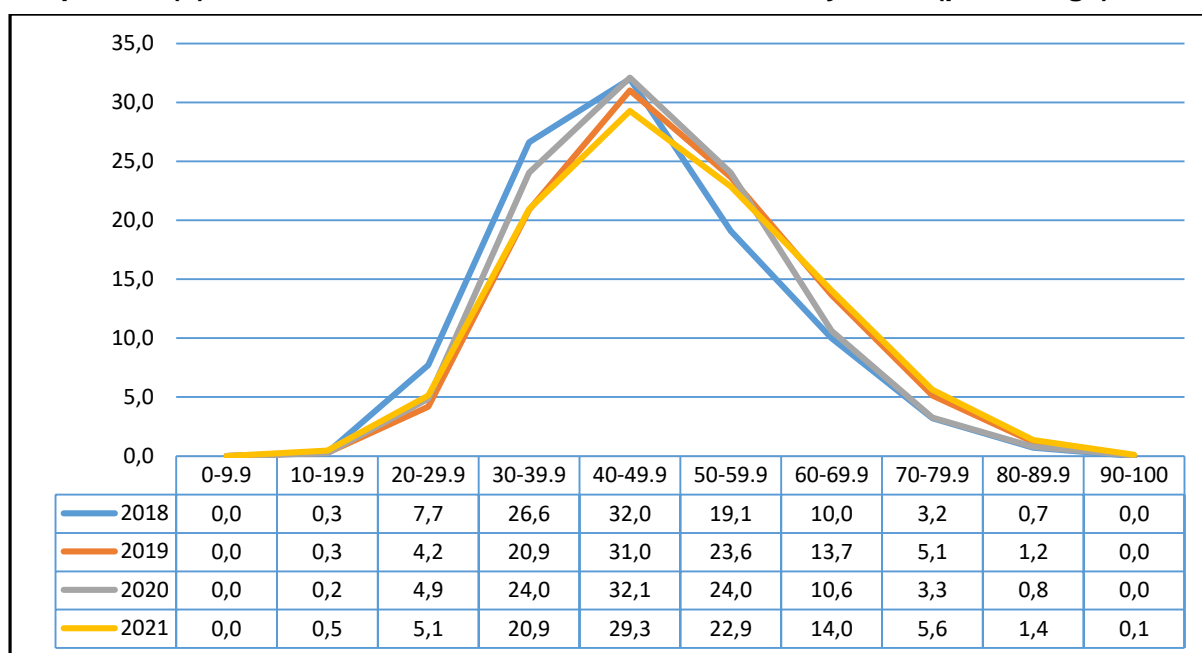
5.3.1 PERFORMANCE TRENDS (2018–2021)

This was the fourth time that this subject was offered as an NSC examination subject. In 2021, 5 675 candidates sat for the Power Systems examination, i.e. an increase of 1 052 in comparison to the previous year. The results reflect that the pass rate in 2021 at 30% (Level 2) was 94,4%, which is consistent with that of 2020.

However, it was encouraging that 44,0% of candidates achieved over 50% this year in comparison to 38,7% of candidates doing so in 2020.

The percentage of distinctions (80%; Level 7) increased from 0,8% in 2020 to 1,5% in 2021. This translates to a significant increase in the number of distinctions from 37 to 85.

Table 5.3.1 Overall achievement rates in Power Systems

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	5 228	4 806	91,9
2019	4 796	4 583	95,6
2020	4 623	4 387	94,9
2021	5 675	5 357	94,4

Graph 5.3.1(a) Overall achievement rates in Power Systems (percentage)

	2018	2019	2020	2021
% achieved at 30% and above	91,9	95,6	94,9	94,4

Graph 5.3.1(b) Performance distribution curves in Power Systems (percentage)

	0-9.9	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	70-79.9	80-89.9	90-100
2018	0,0	0,3	7,7	26,6	32,0	19,1	10,0	3,2	0,7	0,0
2019	0,0	0,3	4,2	20,9	31,0	23,6	13,7	5,1	1,2	0,0
2020	0,0	0,2	4,9	24,0	32,1	24,0	10,6	3,3	0,8	0,0
2021	0,0	0,5	5,1	20,9	29,3	22,9	14,0	5,6	1,4	0,1

5.3.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE POWER SYSTEMS PAPER

General comments

(a)   Based on a sample of the candidates' responses, it is evident that most candidates were still experiencing challenges with interpreting the requirements of the question and were having difficulty with answering questions of a narrative nature.

(b)   Questions that required learners to explain basic operations of circuits were still a challenge because of a lack of content knowledge and insight of the concepts.

(c)   The application of mathematical principles and the expression of responses after analysing circuits, require further attention.

(d)   Selection of the relevant formula/formulae from the formula sheet, manipulation of the formula, correct substitution, calculation and the writing of the correct unit were still a challenge.

(e)   Omission of labels in drawings has resulted in a loss of marks.

General suggestions for improvement

(a)   Use of past NSC papers: It must be noted that past question papers may serve as one of many teaching and learning resources if used properly. These papers may be used for learner assessment, revision purposes and, to a certain extent, teachers may use these papers for self-diagnostic assessment. Every learner must have access to past examination papers from November 2018 to November 2021 as these are based on the current *CAPS* content.

(b)   Revision of relevant Grade 10 and 11 content: Although the NSC examinations only assess Grade 12 content, prior knowledge from Grade 10 and 11 syllabi serve as a foundation to equip and prepare learners to respond to Grade 12 content. It is therefore significant that this prior knowledge be incorporated in their lesson preparations/plan.

(c)   Time management: Learners must be trained in the art of managing their time and to adhere to the suggested time allocations provided in the paper. The mark allocation is a good indicator of the amount of information needed.

(d)   Practical experiments and past papers**:** At the end of each topic in the *CAPS* document, there are practical experiments to be performed to enhance the understanding of the subject content. Teachers are encouraged to perform these practical tasks, which will in turn prepare learners for the practical assessment tasks (PATs).

(e)   For the narrative nature of questions, the responses in the marking guidelines are broken down into key areas of specific content and marks are then awarded to that. A general response will only be awarded one mark. Learners must learn how to respond in the required fashion, which will hone their comprehension skills and eliminate one-word vague responses. Refer to Q5.1.4, Q6.1.1, and Q6.4.4 where the responses are broken down in bullet form and ticks/marks are placed at key areas of specific content.

(f)   For graphical or diagrammatical nature of questions, the responses in the marking guideline are broken down as in Q7.5.

5.3.3 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN THE POWER SYSTEMS PAPER

QUESTION 1: MULTIPLE-CHOICE QUESTION

Common errors and misconceptions

(a)   This type of question is new. Candidates may not have had enough practice in them.

(b)   In Q1.1, candidates confused *unsafe condition* and *unsafe act*.

(c)   In Q1.3, candidates did not know the difference between *leading* and *lagging* when referring to phase angle.

(d)   In Q1.4, candidates did not understand the definition of *selectivity*.

(e)   In Q1.7, many candidates did not know the difference between a *wattmeter* and a *kilowatt-hour meter*.

(f)   In Q1.8 a large number of candidates confused the function of a *step-up transformer* with that of a *stepping up of power*.

(g)   In Q1.11, many candidates did not understand the function of the overload relay in a motor starter.

Suggestions for improvement

(a)   Learners should:
- read carefully when answering these questions;
- not rush through the different possible answers;
- keep in mind that only one answer is the most correct;
- improve their content knowledge in the subject as a whole to perform well in this question;
- be encouraged to read the textbook to gain insight; and
- be encouraged to answer all questions because they just choose the correct answer.

(b)   Teachers are advised to include this type of question in formal and even informal assessment tasks.

(c)   In Q1.1.3, teachers must emphasise the difference between *lagging* and *leading* terminology, including the relationship between current and voltage in an inductive, capacitive and resistive circuit.

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

Common errors and misconceptions

(a)   In Q2.1 candidates confused the function of a *health and safety representative* with that of the *safety officer*. Most candidates wrote the function of a safety officer instead of a safety representative.

(b)   In Q2.2 most of the candidates answered this question by listing general human rights, but they did not relate it to the workplace, hence they did not answer the question correctly.

(c)   In Q2.3 candidates could not differentiate between *unsafe acts* and *unsafe conditions*, as many wrote the definition of both. Many candidates did not know the difference between the two.

(d)   In Q2.4 candidates confused the *types of risk analysis* with those of *categories of risk analysis*.

(e)   In Q2.5 many candidates explained *danger* in the same way as an *unsafe action* or *condition*.

Suggestions for improvement

(a)   It is clear that poor comprehension of the questions was a challenge. Teachers are advised and encouraged to develop activities that require definitions according to the OHS Act and explanations of concepts and terminologies.

(b)   Teachers require content and didactic training on OHS Act.

(c)   Teachers should plan, teach, and assess this topic taking *CAPS* into account at all times. This focuses learner responses in the proper direction and eliminates one-word vague responses.

(d)   The understanding of concepts and terminology and how to describe and express them is posing a huge challenge to the majority of learners. The language barrier seems to be getting worse instead of improving. Learners must be encouraged to read technical literature (journals, technical books and other relevant guides) to familiarise themselves with the language and the syntax (the order or arrangement of words and phrases to form proper sentences) associated with it.

(e)   OHS needs emphasis from Grades 10 and 11, and should be incorporated in practical tasks and infused in teaching rather than being taught in isolation.

(f)   Teachers should identify their shortcomings by answering previous question papers. Their performance will inform them on the questions/sections they have challenges with and those that they are good at. Based on their performance, they could seek assistance to develop themselves.

QUESTION 3: RLC CIRCUITS

Common errors and misconceptions

(a)   In Q3.1 many candidates were unable to recall the definition of *capacitive reactance*. Many did not refer to AC in their attempt to answer the question.

(b)   In Q3.2 most candidates did not state the phase relationship between current and voltage in an inductive circuit.

(c)   In Q3.3.1 and Q.3.4.4 the majority of the candidates could not make L and C, respectively, the subject of the formula from the formulae taken from the formula sheet. This affected the substitution and the answer. Some candidates did not use units or they used incorrect units.

(d)   In Q3.3.2 most of candidates lost marks by omitting the units in the final answer.

(e)   In Q3.3.3 many candidates included a unit in the final answer and lost a mark because power factor has no units. Some candidates used the incorrect formula and calculated the phase angle and not the power factor.

(f)   In Q3.3.4 most candidates did not know that the unity power factor is the same as the power factor is equal to 1

(g)   In Q3.4.1 and Q3.4.2 candidates could not identify the resonant frequency from data given to them.

(h)   Q3.4.2 most candidates could not compare the values of the inductive and capacitive reactances when the frequency increases, as given in the data in FIGURE 3.4B.

(i)   Q3.4.3 many candidates did not consider the engineering notation prefix when calculating the volt drop across the inductor resulting in the loss of 2 marks.

(j)   In Q3.5.2 candidates could not calculate the voltage drop across the inductor as many used the incorrect formula.

Suggestions for improvement

(a)   Teachers should illustrate the phase relationship between I and V in a/an:
- Resistive circuit
- Inductive circuit
- Capacitive circuit

and explain why a circuit is inductive or capacitive.

(b)   Teachers should explain the effect of varying the frequency of the supply in an RLC circuit, the characteristics curve and phasor diagrams of resonance circuits and the conditions of series/parallel resonant circuits.

(c)   The following should be considered:
- Lesson plans developed by teachers and not by subject advisors are key to these challenges, for example:
  - To reflect on what worked well during the presentation, and what could have been done differently for further improvement of the next lesson plan
  - To reflect on prior learning to introduce the content to be learned
- When covering calculations, integrate relevant mathematical concepts e.g. manipulation of formulae.
- Focus on identification of appropriate formulae from the formula sheet and application thereof.
- Develop an assessment task based on the following:
  - Identification of the formula for specific calculations
  - Manipulation of formulae
  - Units for specific quantities, e.g. voltage, current, resistance, impedance, frequency, phase angle, bandwidth, etc.
  - Prefixes, e.g. nano, micro, milli, kilo and the conversion thereof
  - Use of the calculator
  - These assessment task should also be implemented in section with calculations, e.g. in semiconductors and switching circuits

(d)   The definitions of the terms, explanations and descriptions of concepts that are likely to be asked in the examination should be summarised in a booklet and handed to learners at the beginning of the year.

(e)   Learners must be trained to read the question carefully and to look at the mark allocation. The number of facts provided must correlate with the number of marks.

(f)   Learners need to read questions with understanding to answer appropriately. Similar questions should be given during the year in preparation for the final examination.

(g)   The application and understanding of data taken from these circuits to answer theoretical style questions is a major problem currently. The practical building of RLC circuits and the checking of the waveforms on the oscilloscope is a good way of reinforcing the theory.

QUESTION 4: THREE-PHASE AC GENERATION (SPECIFIC)

Common errors and misconceptions

(a)   In Q4.1.1 most candidates did not name the processes but merely described the diagram.

(b)   In Q4.1.2 candidates were unable to draw the generated waveforms correctly at point A. Of those who attempted to draw it, many did not include the correct phase and sequence.

(c)   In Q4.1.3 many candidates focused on a step-up transformer increasing the voltage but they did not mention how this affects the current in the transmission lines which reduces the copper losses.

(d)   In Q4.1.4 candidates did not know why a *star connection* would be used at transformer 3 to supply both three-phase users and single-phase users.

(e)   In Q4.2 candidates used incorrect units, incorrect formulae and incorrect numbering of questions. This resulted in the loss of many marks.

(f)   In Q4.4 the concept of leading and lagging power factor was a challenge, as most candidates were unable to analyse/read/interpret the reading on an analogue power factor meter.

Suggestions for improvement

(a)   It is advisable to develop a chart as part of teaching aids, where the three powers, namely: *active power*, *reactive power*, *apparent power* and the *power factor* will be explained or defined. These terms should be put on the wall so that learners become familiar with them. This technique can also be used for other sections where similar misconceptions exist.

(b)   Reading the question with understanding is crucial in questions of this nature. Candidates tend to provide inappropriate answers to questions only if they did not read the questions carefully. The skill of reading the questions with understanding can be honed though constant practice throughout the year. Learners should be taught to analyse the question before they attempt to answer it. In interpreting and understanding of questions, focus should be placed on the following verbs: explain, define, describe and explain.

(c)   Teachers should spend time in explaining the following concepts:
   * True power
   * Apparent power
   * Reactive power and efficiency
   * Power factor.

(d)   Calculations count for approximately 50% of the marks in the question paper. Learners should be trained on how to select the correct formula, manipulate this where necessary, and to substitute correctly, e.g. 2 kW should be written as 2 kW or 2 000 and not as 2).

$$P_T = P_1 + P_2$$
$$= 1{,}2k + 2{,}3k$$
$$= 3{,}5 \text{ kW}$$

or

$$P_T = P_1 + P_2$$
$$= 1200 + 2300$$
$$= 3{,}5 \text{ kW}$$

or

$$P_T = P_1 + P_2$$
$$= 1{,}2 \times 10^3 + 2{,}3 \times 10^3$$
$$= 3{,}5 \text{ kW}$$

The units must also be included at the end of the final answer. Learners should be exposed to more calculations and in the process, identify and address omissions (formulae, units, prefixes, etc.), knowledge gaps and misconceptions. Learners must also be encouraged to refer to the formula sheet because it gives the summaries of laws and principles.

(e)   Learners made careless mistakes that lost them many marks unnecessarily. The mechanics and procedures used when presenting calculations was lacking this year. Learners require more practice in this approach and constant checking and feedback from teachers.

(f)   Teacher must ensure that candidates understand the three main stages of the National Grid in a block diagram. A video can also be used for demonstrations

(g)   Teachers should ensure that their learners understand the following:

- How to draw and interpret a waveform diagram of three-phase AC generation including their phase angles
- Why the AC voltage has to be stepped up after generation before transmission and step-down before distribution to household and industries
- The purpose of each transformer in each stage of the network distribution and simulate the distribution network using software.

QUESTION 5: THREE-PHASE TRANSFORMER (SPECIFIC)

Common errors and misconceptions

(a)   In Q5.1.1 candidates could not identify the parts of a three-phase transformer.

(b)   In Q5.1.2 the cooling methods for three-phase transformers were not given in full. Instead of *oil natural air forced* candidates just answered as *oil cooled* and marks were lost here. Candidates should be encouraged to write out the full name of cooling methods and not use abbreviations.

(c)   In Q5.1.3 candidates did not list the specific protection devices. They incorrectly listed the causes and symptoms of overloading a transformer.

(d)   In Q5.1.4 many candidates confused the operation and purpose of a solid-state transformer with a rotating motor. Most candidates explained the construction of transformers and their application instead of a step-down transformer's operation.

(e)   In Q5.2 candidates were not familiar with the core types of three-phase transformer.

(f)   In Q5.3.3 candidates wrote the ratio of the transformer in fractional form, e.g. $\frac{5}{1}$ and others in decimal form, e.g. 4.95: 1, instead of 5:1.

(g)   In Q5.3.5 an incorrect formula used in the calculation resulted in a loss of marks.

Suggestions for improvement

(a)   Teachers must show learners practical identification of a part and how the part contributes to the functioning of the transformer.

(b)   Teach learners the difference between:
- Coolant and the method of cooling in transformers;
- Step-up transformer (transformer that increases the voltage on its secondary winding with respect to the primary) and a step-down transformer (transformer that decreases the voltage on the secondary winding with respect to the primary) and how each operates.

(c)   Teach learners the ratio between the numbers of turns of the primary windings to that of the secondary windings and that it has no units. This ratio is written with a colon, e.g. 6:1.

(d)   Use practical examples when teaching.

(e)   Familiarise learners with protective devices.

(f)   Teach learners to change values; manipulate formulae and use the correct units for the different power calculations. Assess them on these calculations regularly to encourage learners to pay attention to these aspects.

QUESTION 6: THREE-PHASE MOTORS AND STARTERS (SPECIFIC)

Common errors and misconceptions

(a)   In Q6.1.2 candidates could not explain how a rotating magnetic field was created in the stator windings. Many of them described the assembly, construction or connection of the stator windings.

(b)   In Q6.1.4 candidates could not state the factors that determined the speed of rotation in a three-phase induction motor.

(c)   In Q6.2.2 candidates' responses were vague and they just said 'swap lines'. The specific and concise nature of the subject was lost.

(d)   In Q6.2.3 candidates confused motor testing with mechanical inspection. Candidates did not realise that the insulation resistance test is an electrical test and that before testing the motor the power lines must be disconnected and the connecting plates must be removed.

(e)   In Q6.3.1 candidates used incorrect pole pairs resulting in an incorrect answer.

(f)   In Q6.3.3 candidates used an incorrect formula and many did not write the unit. They lost marks for this.

(g)   In Q6.4 most candidates did not know the application of components used in the manual sequence starter.

Suggestions for improvement

(a)   Teachers need to encourage learners to understand the formula in relation to theory.

(b)   This challenge in Q6.4 might be attributed to lack of practical work at school. Teachers must use digital media, e.g. the internet or videos.

(c)   The control circuits, as stipulated in the *CAPS*, must be drawn on the chart with components, function and the operation in sequential form.

(d)   Teach learners the difference between *motors* and *motor starters.* More focus should be given to the sequence starter and star-delta starters that learners are not as familiar with as with the normal direct-on-line starter and forward-reverse starters. Teach them that each starter has its own name and function.

(e)   Latching is a very important concept as it is used in starters as well. Teachers should focus on insight information as the questions are not posed in a straight-forward way. Use keywords, such as *why*, *how*, *describe* and *explain*, when teaching the theory part of the subject. Teach candidates to explain and not simply answers.

(f)   More calculations on speed formulae need to be practised.

(g)   Teachers should explain to learners that phase values will never be greater than line values; they can, however, be equal.

(h)   Explain/describe:
- How the control circuit is operated
- Function of each component in the circuit
- Analysis of the control circuit
- The effect that an inserted fault will have on the operation of the circuit. This is usually a 3-mark question.

(i)   It is important that learners are taught the theory behind the starters. If learners know the operation of each starter and the function of each component in the starters, they should be able to answer all the questions in Q6.

QUESTION 7: PROGRAMMABLE LOGIC CONTROLLERS (PLCs) (SPECIFIC)

Common errors and misconceptions

(a)   In Q7.1.1 candidates confused *types of hardware modules* with *discrete components and software*.

(b)   In Q7.1.2 candidates wrote vague, generalised or incorrect answers. The marking guidelines focused on specific concise responses.

(c)   In Q7.1.3 candidates did not realise that the word *component* referred to a hardware device.

(d)   In Q7.2 candidates did not make reference to the time taken to complete one scan cycle. Their response referred to it as a period of time of operation.

(e)   In Q7.3 candidates wrote vague, generalised responses that did not focus on what software is in reference to PLCs, where it is installed and what it instructs.

(f)   In Q7.5 candidates are still confused about whether the switches should be open or closed but the marking guidelines catered for that. A pattern that is emerging often is that learners are drawing a mirror image of the programme and this poses a problem because the program only works in a left to right sequence. A correct mirror image is incorrect resulting is a loss of many marks. This programme will not operate the programming software for PLCs. Note that interlocking contacts MC2 NC and MC1 NC must be closed to indicate interlocking contacts.

(g)   In Q7.6.1 candidates could not identify the DC to AC inverter in the circuit.

(h)   In Q7.6.4 most candidates did not know the vector drives.

(i)   In Q7.6.3 candidates did not know the advantages of variable speed drives.

(j)   In Q7.8 most candidates could not explain regenerative braking energy when the momentum drives the motor.

Suggestions for improvement

(a)   The specific and concise nature of the subject must be stressed by teachers when delivering the content.

(b)   Variable speed drives and regenerative braking need a lot more attention in terms of block diagrams, basic purpose of blocks, applications and advantages.

(c)   Explain what sensors are. The definitions and uses of sensors should be given in full.

(d)   Teachers should show the hardware components of the PLC practically to learners. Teach them all the hardware components and not only the CPU.

(e)   Teach learners what applications are. Teach them to look for the specific words; in this case it is the overload sensor.

(f)   Extra time should be given to teaching the *latching concept* to learners. Teachers can show this practically as well.

(g)   Teach learners the function of the different components.

(h)   Teachers should allocate more time to teaching *VSDs*. Focus should be on what is happening at each stage and how it is achieved.

(i)   With regard to Q.7.7, teachers must teach the purpose or function of regenerative braking and the energies involved in this process. Note that learners learn differently and at different paces, therefore teachers must consider all learners when preparing lessons. Some learners learn more effectively when they see and touch, while others learn more effectively though verbal or visual ways.

(j)   Teachers need to explain and demonstrate to learners how the conversion of hard wiring to ladder logic diagram is done, and show correct labelling of inputs and outputs. Note that ladder logic diagrams are drawn from:
   - Left power rails with input instruction to right power rails with output instruction
   - Top to bottom with rungs connected between two power rails
   - The ladder logic diagram drawn should use the Engineering Graphics and Design (EGD) approach and not crude freehand drawings.

(k)   Teachers should assist learners to:
   - Identify the latching circuit, which is the start button connected in parallel with the normally open contact (N/O) of the coil
   - Understand the purpose of latching
   - Explain the different types of contact used for latching, which is normally open contact (N/O)

(l)   Teachers should assist learners to:
- Understand the purpose of interlocking
- Use the correct symbols for interlocking
- Explain the concept of series connection as used in interlocking circuit
- Perform the practical experiment.