CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

MAY/JUNE 2014

ELECTRICAL AND ELECTRONIC TECHNOLOGY

GENERAL COMMENTS

One hundred and eighty candidates registered for Unit 1, however only 161 candidates wrote Paper 01 and 163 candidates wrote Paper 02. Three of the candidates who wrote this unit earned Grade I and in total, 75 per cent of the candidates earned Grades I–V.

Ninety-three candidates registered for Unit 2 and both Papers 01 and 02 were written by 82 candidates. Eighty per cent of the candidates earned Grades I–V.

There has been an increase in registration for this subject, particularly Unit 2.

As in previous years, performance at Grades I–III in both units has been weak with the majority of passes being earned at Grades IV and V. However, there are signs of improvement in some areas over previous years. The poor performance at the higher grades could be a result of one or a combination of factors including:

1. The ill preparedness of candidates for the subject, both in the theoretical and practical aspects
2. The source from which candidates are drawn – one where the foundation needed for good performance in this subject has not been provided
3. The weak mathematics and science background of candidates
4. The need for training and orientation of some teachers in the delivery of subject content which covers the theoretical and practical aspects of both the electrical and the electronics components
5. The need for appropriate textbooks, materials and other resources inclusive of tools, equipment and machines being available in the centres to support this subject.

DETAILED COMMENTS

UNIT 1

Paper 01 – Short-Answer Questions

This paper consisted of 15 short-answer questions, each worth six marks. Candidates were required to answer all questions. The paper was worth 90 marks. Candidates' overall marks ranged from 1 to 57. The mean score for this paper was 18.

Module 1: DC Circuit Theory (Questions 1 – 5)
Candidates were required to use fundamental laws and theory to solve problems associated with DC circuits.

Question 1

This question tested knowledge of Ohms law and resistance. Candidates were required in Part (a) to state Ohms law; in Part (b), they were given the resistance marking on a resistor and asked to state its resistance and in Part (c), the diameter and resistance of a wire were given and candidates were required to calculate its resistance if the diameter is reduced. In response to Part (a), most candidates were able to state Ohms law. However, the majority experienced difficulty interpreting the correct value of the resistor for Part (b), and could not conduct the needed calculations for Part (c) to determine the resistance of the wire when the diameter is reduced.

Question 2

In Part (a), candidates were asked to state the meaning of the term *relative permittivity* and in Part (b), they were required to (i) calculate the relative permittivity of the dielectric of a capacitor, given relative information and (ii) suggest one suitable material for the dielectric. For Part (a), many candidates were unable to state the meaning of the term relative permittivity. However, in Part (b) (i), they were able to apply the right formula and calculate the relative permittivity. Difficulty was experienced in determining a suitable material for the dielectric.

Question 3

In Part (a), candidates were required to define the terms *dielectric* and *electric flux density* and in Part (b), they were asked to calculate (i) the total capacitance and (ii) the total energy stored when all the capacitors in a given series–parallel capacitive circuit are charged. Most candidates were able to define the terms dielectric and electric flux density. However, some candidates were unable to correctly analyse the capacitive network, thus selecting and manipulating the wrong formulae to complete the calculations.

Question 4

Candidates were required in Part (a), to state what happens when the insulation of an inductor fails; in Part (b), they were required to state the meaning of *cumulative coupling* as it relates to two coils connected in series; and in Part (c), candidates were asked to calculate the electromotive force in a solenoid with a decrease in current. For Part (a), the majority of candidates demonstrated knowledge of what happens when the insulation of an inductor fails. Most candidates could not state the meaning of cumulative coupling in Part (b). Their weak responses to this part of the question indicated that they did not fully grasp the concept of cumulative coupling. In Part (c), the majority of candidates was able to use the correct formula to calculate the electromotive force.

Question 5

Given a series–parallel resistive circuit, candidates were required to determine the Norton equivalent circuit. The majority of candidates was able to calculate the total resistance of the parallel branch of the circuit, but was unable to determine the Norton equivalent circuit. Most candidates could not execute the needed calculations and therefore could not redraw the circuit.

Module 2: Analogue Electronics and Communications (Questions 6 – 10)

Basic analogue electronics and communications concepts were covered in this module which proved to be somewhat challenging. Most candidates scored low marks.

Question 6

Part (a) required candidates to state the name of a given schematic of an electronic circuit. In Part (b), candidates were required to sketch the output waveform of the given circuit and in Part (c), explain the operation of the circuit. For Part (a), most candidates were able to correctly state the name of the circuit. However, several claimed that it was a *rectifier* circuit instead of a *clipper* circuit due to the presence of the zener diodes. As a result, they were unable to correctly sketch the output waveform requested in Part (b). Although most candidates correctly recognized the circuit, they experienced much difficulty explaining its operation, as required for Part (c).

Question7

Candidates were asked in Part (a) to define the term *ground wave*; in Part (b), they were asked to name the most effective conductor which enables a ground wave to travel very far distances; and in Part (c), candidates had to explain the meaning of *antenna polarization*. Most candidates were able to define the term *ground wave* but the majority of them could not name the most effective conductor to enable the ground wave to travel far distances.

Question 8

In Part (a), candidates were required to define the terms *frequency modulation* and *frequency deviation*. In Part (b), they were asked to calculate (i) the carrier swing and (ii) the highest frequency attained by a frequency modulated carrier that is modulated by an audio signal. Most candidates could not give accurate definitions as required in Part (a), and found the calculations needed to correctly answer Part (b) to be challenging.

Question 9

Candidates were provided with an oscillator circuit and were required, in Part (a), to state the name of the oscillator; in Part (b), to determine the resonant frequency and the feedback fraction; and in Part (c), to identify three general features of an ideal operational amplifier. Part (a) was widely known by most candidates who easily identified the name of the oscillator. A majority of the candidates were able to state the formula for resonant frequency but could not state the formula for feedback fraction. Candidates easily identified three general features of an ideal operational amplifier as required for Part (c).

Question 10

Candidates were given the circuit of a common emitter amplifier and were required to calculate, in Part (a), the voltage across the base resistor; in Part (b), the current flowing through the base resistor; and in Part (c), the collector current. Most candidates found this question to be very challenging because they were unable to correctly use the formulae to complete the calculations for Parts (a), (b) and (c).

Module 3: Introduction to Power Systems (Questions 11 – 15)

This module, which introduces candidates to electrical power systems, continues to be the most challenging of the three modules. From a possible 30 points, the highest score was 22.

Question 11

For Part (a), candidates were required to draw the magnetic flux lines for a given configuration of magnets and, for Part (b), they were asked to define the term *magnetic flux density* and give its symbol and its unit. Most candidates were able to answer Part (a) by drawing the diagram correctly. However, some of them experienced difficulty presenting the direction of the flux lines for the magnets. Most candidates could not define the term magnetic flux density and were unable to provide its symbol and unit.

Question 12

This question required candidates, in Part (a), to list three differences between a bimetallic relay and a solid state relay and, in Part (b), to sketch and label the cross section of a cylindrical fuse. Many candidates, in response to Part (a), could not readily list three differences between a bimetallic relay and a solid state relay. In response to Part (b), most candidates were able to draw the diagram of a fuse but could not label it.

Question 13

In Part (a), candidates were given relevant information and required to calculate the speed of a six-pole DC motor. In Part (b), they were asked to state why shunt-wound, series-wound and compound-wound machines are referred to as self-excited machines. Candidates, in response to Part (a), were able to complete some aspects of the needed calculations correctly by inserting the data given in the required formula. Part (b) presented some difficulty since candidates could not correctly explain the principle of operation of a self-excited machine. It was evident that candidates lacked a good working understanding of a DC machine and hence were unable to adequately answer the question.

Question 14

In Part (a), candidates were required to state the meaning of the terms *armature reaction* and *commutation* and, in Part (b), they were asked to use a suitable diagram to describe the compound-wound DC machine winding connection. Most candidates found it difficult to define the terms as required for Part (a). However, in response to Part (b), most candidates drew a suitable diagram and adequately described the compound-wound DC machine winding connection.

Question 15

For Part (a) (i), candidates were required to define the term *power line carrier* and for Part (a) (ii), they were asked to state two advantages of power line carriers. Part (b) (i) required candidates to define the term *leased lines* as applied to power system communications while Part (b) (ii) asked them to state two disadvantages of leased lines. In response to Parts (a) (i) and (ii), many candidates were able to define the term power line carrier and state two of its advantages. In Part (b), candidates adequately defined the term leased lines but were unable to adequately state two disadvantages.

Paper 02 – Essays

Candidates were required to answer six questions which accounted for 150 marks. Questions 1, 4 and 7 were compulsory and each worth 30 marks. Candidates were required to select one of the remaining two questions in each of the three modules. Each question was worth 20 marks. Candidates' scores ranged from a low of 2 to a high of 97.

Module 1: DC Circuit Theory (Questions 1 – 3)

<u>Question 1</u>

In Part (a), candidates were given a DC network with two voltage sources and were required to state the superposition theorem, use the superposition theorem to determine the current, I, in the given network, calculate the power dissipated in R_1 and calculate the resistance of R (made of copper) when its temperature reached 80^0 C. In Part (b), candidates were required to state Kirchhoff's first and second laws and use a given mesh network with two voltage sources to find the current, I_1, flowing in loop 1. In Part (c), candidates were required to explain Thevenin's theorem, use a given resistive DC network to calculate the equivalent internal resistance of the network, and explain the term *resistance matching*.

Some candidates were unable to state the superposition theorem required for Part (a) (i). In response to Part (a) (ii), most candidates could not calculate the current, I, and therefore could not calculate the power dissipated in R_1 as required for Part (a) (iii). For Part (a) (iv), most candidates stated the formula correctly but could not determine the correct resistance because they placed incorrect values in the formula.

Although for Part (b) (i), some candidates correctly stated Kirchhoff's Laws, the question posed a problem for several others. Also, in Part (b) (ii), many candidates encountered problems when they tried to analyse the network to complete the required calculations.

Most candidates could not explain Thevenin's theorem as they were required to do in Part (c) (i). In addition, candidates found the required calculations for Part (c) (ii) challenging and, therefore, could not complete them. Candidates experienced further difficulty when they tried to explain the term *resistance matching*, as required for Part (c) (iii).

Question 2

This question was designed to test candidates' knowledge and understanding of capacitors. Candidates were expected, in Part (a), to define the term *capacitance*, state and define the *unit of capacitance*, state why variable capacitors require two sets of rigid plates, and name one application of a variable capacitor. In Part (b), candidates were given information on a capacitor and a resistor connected in series across a DC supply. From this, they were required to draw a labelled circuit diagram to show the details. Candidates were also asked to calculate the circuit time constant and the initial charging current as well as sketch the waveforms for both the pd across the capacitor and the charging current. In Part (c), candidates were required to outline three properties of the lines of force in an electric field.

Candidates were quite conversant with Parts (a) (i), (ii), (iii) and (iv) and demonstrated good knowledge of capacitors. Candidates also demonstrated good knowledge of the information required for Parts (b) (i), (ii), (iii), and (iv). Part (c) was the most challenging; the majority of candidates could not outline three properties of the lines of force in an electric field.

Question 3

This question tested candidates' knowledge of inductors. They were required, in Part (a), to (i) define the *unit of inductance*, (ii) list three ways to increase the inductance of a coil and (iii) given relevant information of an inductor, calculate the number of turns of wire for the inductor. In Part (b), candidates were required to explain the term *coupling coefficient* as it relates to inductors that are tightly coupled and loosely coupled. In Part (c), information was given on three inductors connected in series and candidates were required to (i) draw a labelled circuit diagram, (ii) calculate the circuit time constant, and (iii) calculate the final current in the circuit. In Part (d), candidates were required to state where the energy is stored in an inductor.

Candidates had a reasoned approach to answering Parts (a) (i) and (ii) and demonstrated sound knowledge of the information required. However, Part (a) (iii) was found to be challenging; the majority of candidates who attempted this question avoided answering this part and those who tried could not correctly complete the calculations required. Candidates were able to satisfactorily explain the term *coupling coefficient* when used with inductors that are tightly and loosely coupled respectively. Most candidates were able to adequately draw a labelled circuit diagram and satisfactorily complete the calculations required for Parts (c) (ii) and (iii). Candidates also demonstrated knowledge of where energy is stored in an inductor to complete Part (d).

Module 2: Analogue Electronics and Communications (Questions 4 – 6)

Question 4

All candidates were required to answer this question which tested their knowledge of the semiconductor diode. In Parts (a) and (b), respectively, candidates were required to state what is meant by the terms *depletion layer* and *barrier potential*. For Part (c), candidates were asked to use a block diagram to explain current flow in a PN junction diode and in Part (d), they were required to use a given full wave bridge rectifier circuit diagram to (i) explain how the circuit operates, (ii) draw the circuit diagram of a typical resistive filter that can be used with the rectifier and (iii) calculate the mean load current and the r.m.s current. In Part (e), candidates were required to state the function of a zener diode when used in a power supply and indicate how it is placed in the circuit.

In Part (a), many candidates were able to state the meaning of the term depletion layer but were unable, for Part (b), to accurately state what was meant by the term barrier potential. Some candidates, in response to Part (c), were unable to accurately draw the block diagram and explain current flow. Candidates' response to Part (d) (i) indicated that they were not fully aware of the operation of the rectifier circuit and experienced difficulty trying to explain the same. However, they experienced little difficulty drawing the resistive filter for the rectifier required for Part (d) (ii). In response to Part (d) (iii) a), the majority of candidates found it difficult to calculate the mean load current but were better prepared to calculate the r.m.s. current as required for Part (d) (iii) b). In response to Part (e), most candidates were able to correctly state the function of the diode and how it is placed in the circuit.

Question 5

Candidates were required, in Part (a), to state the formula used to calculate the modulation factor of an amplitude modulated waveform and indicate what each of its symbols represents. In Part (b), candidates were given a block diagram of an AM superheterodyne receiver and they were required to (i) calculate the frequency of the local oscillator, (ii) state the function of a) the detector and b) the automatic gain control. In Part (c), candidates were required to state the function of three stages of an FM receiver: (i) limiter, (ii) IF amplifier, and (iii) DC emphasis network. In Part (d), candidates were required to state the effects that noise causes on the amplitude of both AM and FM waveforms at the receiver.

In Part (a), many candidates did not appear to be aware of the correct formula to be used and therefore could not correctly answer the question. However, most candidates were able to correctly calculate the local oscillator frequency for Part (b) (i). Responses to Parts (b) (ii) and (iii) indicated that most candidates were aware of the function of the detector but had limited knowledge of the automatic gain control. In response to Parts (c) (i), (ii) and (iii), candidates demonstrated some knowledge of the limiter, the IF amplifier and the DC emphasis network, but not enough to accurately answer the parts of the question. The majority of candidates, in response to Part (d), demonstrated correct knowledge of the effects of noise on both AM and FM waveforms.

Question 6

This question focused on candidates' knowledge of transistors. Part (a) required candidates to explain how a transistor must be biased for normal operation, while Part (b) required them to state the formula used to calculate the DC current gain of a transistor in the common emitter configuration. In Part (c), candidates were given a common emitter transistor circuit diagram and were required to calculate the (i) DC base voltage, (ii) emitter and collector currents and (iii) collector and emitter voltage. For Part (d), candidates were required to explain what is meant by the term *thermal runaway* as applied to a transistor connected in the common emitter configuration.

Some candidates, in response to Part (a), demonstrated good knowledge of how a transistor must be biased. Most of the candidates in response to Part (b) were able to correctly state the required formula. Some of the candidates were able to adequately respond to Parts (c) (i), (ii) and (iii), whilst others were unable to identify the resistor across which the base voltage is developed and, therefore, could not answer these parts of the question correctly. Identification of the required formula to conduct the calculations also presented a problem for most candidates. Only a few candidates attempted Part (d); this indicated that their knowledge of *thermal* runaway was limited.

Module 3: Introduction to Electrical Power Systems (Questions 7 – 9)

Question 7

This question required candidates, in Part (a), to (i) describe the armature as it relates to a DC machine and (ii) sketch and identify the two winding configurations in the armature construction of a DC machine. In Part (b), candidates were given relevant information on a four-pole DC armature and they were required to calculate the (i) terminal voltage at no load, (ii) total power generated on full load, and (iii) efficiency of the machine. In Part (c), candidates were required to (i) identify an alternative armature winding construction for the DC machine and state its number of parallel paths, (ii) state the impact of the alternative armature winding identified in (i) on the terminal voltage and the total power generated on full load. In Part (d), candidates were required to (i) sketch and label speed-current plots for shunt, series and compound motors on one graph, (ii) explain two methods employed to achieve speed control of a DC motor and (iii) name two applications of a DC motor.

Candidates were able to adequately respond to Parts (a) (i) and (ii). Parts (b) (i), (ii) and (iii) were very challenging for candidates due to the fact that they could not complete the required calculations. In most cases, candidates were unable to identify and utilize needed formulae for the required calculations. Some candidates in response to Parts (c) (i) and (ii) demonstrated knowledge of the information needed to adequately answer the sub-sections of the question. In response to Parts (d) (i), (ii) and (iii), most candidates were able to answer the sub-sections of the question correctly.

Question 8

This question required candidates, in Part (a), to (i) outline the operation of a frequency relay, (ii) list four reasons why generators in power systems are equipped with frequency relays and (iii) list four conditions which can activate frequency relays. Part (b) asked candidates to distinguish between a fuse and a circuit breaker and to indicate the use of each in a typical household. In Part (c) (i), candidates were to suggest two possible causes for a blown fuse associated with a new household electric kettle, and (ii) sketch a graph to show the inverse characteristic of a fuse. Parts (a) (i), (ii) and (iii) were found to be most challenging for many candidates who could not demonstrate enough knowledge of frequency relays to adequately answer the sub-sections of Part (a). Most candidates were able to adequately answer Part (b) and the sub-sections of Part (c).

Question 9

This question required candidates to (a) state Lenz's law, (b) state Faraday's law and (c) define each of the following terms and provide symbols and units for each (i) *relative permeability*, and (ii) *reluctance*. In Part (d), candidates were required to use the information given in a figure of a mild steel ring with magnetization characteristic of soft magnetic materials to (i) calculate the current in the coil required to produce a flux density of 1.1 T and (ii) with a 2mm air gap created in the ring, calculate the reluctance of the air gap.

The majority of candidates adequately answered Parts (a), (b) and (c) (i) and (ii). Parts (d) (i) and (ii) required several calculations. However, most candidates could not present the required formulae needed for each section and therefore, could not complete the required calculations.

UNIT 2

Paper 01 – Short-Answer Questions

Candidates were required to attempt all questions from this paper which accounted for 90 marks. The lowest score achieved was five while the highest score was 65.

Module 1: AC Circuit Theory (Questions 1 – 5)

Candidates were required to use fundamental laws and simple theory to solve problems associated with simple AC circuits. From a possible maximum of 30 marks, the highest score was 25 and the lowest score was two.

<u>Question 1</u>

In Part (a), candidates were given information on a resistor and a pure inductor connected in series across a 110 V, 60 Hz supply, and they were required to calculate (i) the circuit current magnitude and (ii) the phase angle between the circuit current and the applied voltage. In Part (b), candidates were required to sketch a phasor diagram for the circuit current with reference to the applied voltage. Most candidates were able to calculate the circuit current required in Part (a) (i) but experienced difficulty calculating the phase angle in Part (a) (ii). Candidates also experienced difficulty sketching the phasor diagram for the circuit current with reference to the applied voltage in Part (b).

<u>Question 2</u>

Candidates were asked in Part (a) to define the following terms in relation to an AC sinusoidal wave: (i) *period*, and (ii) *average value*. In Part (b), candidates were given that an alternating voltage has the equation $V = 141.4 \sin 377t$, and they were required to calculate (i) the frequency, and (ii) the r.m.s. voltage. Most candidates defined the terms for Part (a); however, they were unable to calculate the frequency and the r.m.s. voltage as required in Part (b).

<u>Question 3</u>

In Part (a), candidates were given two circuit measurements and they were required to use complex arithmetic to calculate the circuit impedance Z and express it in rectangular notation. In Part (b), candidates were required to define the term *Q factor* and state its formula. Most candidates had difficulty using complex arithmetic to calculate the circuit impedance and expressing it in rectangular notation. However, the majority of candidates were able to define the term Q factor.

Question 4

This question tested candidates' knowledge of filters. Candidates were required in Part (a) to define the terms *filter* and *noise*. In Part (b), candidates were required to explain what is meant by the *cut-off frequency* of a filter. Most candidates attempted Parts (a) and (b) and gained most of the allotted marks by correctly defining the terms. However, some found difficulty explaining what is meant by the cut-off frequency of a filter.

Question 5

In Part (a), candidates were given a figure showing a frequency response graph. From this, they were required to (i) identify the type of filter and (ii) name the area represented by X on the graph. In Part (b), candidates were required to draw the symbols for low pass and high pass filters. In Part (c), candidates were given a drawing of a typical RC filter and were required to calculate the cut-off frequency. Parts (a) and (b) were satisfactorily answered by most candidates who demonstrated knowledge of filters; however, in Part (c), most candidates could not provide the right formula to enable them to correctly calculate the cut-off frequency of the RC filter.

Module 2: Digital Electronics and Data Communications (Questions 6 – 10)
Basic digital electronics and communications concepts were assessed in this module. Only a few candidates seemed to understand this module with three of them scoring 50 per cent or more of the 30 available marks.

Question 6

Part (a) required candidates to draw the symbol for a thyristor; in Part (b), they were asked to describe a thyristor and for Part (c), candidates were required to draw and label a diagram to show the static characteristics of a thyristor. In Part (a), most candidates were able to draw the symbol of the thyristor, but experienced some difficulty describing the thyristor as required in Part (b). Candidates also experienced difficulty drawing and labelling the required diagram.

Question 7

Candidates were required, in Part (a), to state two applications of the 'D' type flip flop and, in Part (b), to describe the function of a *counter* in logic circuits. For Part (a), most candidates were able to at least provide one application of the 'D' type flip flop, but experienced difficulty in Part (b) to accurately describe the function of a *counter*.

<u>Question 8</u>

For Part (a), candidates were required to draw the symbols and state the Boolean expressions for (i) a three input AND gate and (ii) a three input OR gate. In Part (b), candidates were required to state the difference between *FAN-IN* and *FAN-OUT* as they relate to logic circuits. For Part (a), most candidates demonstrated knowledge of logic circuits by providing the required symbols and stating the Boolean expressions. In Part (b), however, they were unable to correctly state the difference between FAN-IN and FAN-OUT as related to logic circuits.

<u>Question 9</u>

Candidates were required in Part (a), with reference to D/A converters, to explain what is meant by the terms *resolution* and *accuracy*. In Part (b), candidates were required to calculate the maximum output voltage of an 8-bit converter with a step size of 10 mV. Most candidates attempted to answer Part (a) but could not correctly define the two terms and in Part (b), they experienced difficulty completing the required calculations.

<u>Question 10</u>

In this question, candidates were required for Part (a), to state the formula used to calculate noise factor as it relates to communication systems and for Part (b), to identify where in a computer network, a network interface card is used and state two factors that must be considered when choosing the card. In Part (c), candidates were required to explain the term *frequency shift keying* (FSK) used in digital modulation techniques. The majority of candidates avoided answering Part (a) and appeared not to be knowledgeable about the formula required to calculate noise factor. In Part (b), some candidates demonstrated knowledge of a network interface card and gave at least one factor that must be considered when choosing the card. Some candidates also demonstrated that they had a general idea of what was meant by the term FSK used in digital modulation techniques.

Module 3: Introduction to AC Machines (Questions 11 – 15)

In previous years, this module posed significant challenges to candidates; however, there are signs that candidates are beginning to better understand the requirements. From a possible 30 marks, the highest score was 23 and the lowest score was zero.

<u>Question 11</u>

Part (a) required candidates to state what must be done to make a synchronous machine function as either a motor or a generator and Part (b) asked them to explain the terms *armature reaction* and *synchronous speed* as each is related to a synchronous generator. Some candidates displayed limited knowledge of what must be done to make a synchronous machine function as either a motor or a generator. In Part (b), most candidates were unable to correctly explain the terms armature reaction and synchronous speed. This question proved to be challenging for most candidates.

Question 12

This question tested candidates' knowledge of transformers. In Part (a), candidates were required to give one reason why the equivalent circuit of a transformer is useful, while in Part (b), they were required to use a diagram to explain how an air core transformer is constructed and indicate one advantage and one disadvantage of using it. In Part (a), some candidates correctly stated that *the transformer equivalent circuit is a powerful analytical tool*. Though most candidates were able to draw the required diagram for Part (b), many were unable to indicate one advantage and one disadvantage of using the air core transformer.

Question 13

In this question, candidates were required to state three advantages and three disadvantages of a synchronous motor. The majority of candidates found this question to be very challenging; they demonstrated limited knowledge of the advantages and disadvantages of a synchronous motor.

Question 14

This question required candidates, in Part (a), to define the terms *slip* and *plugging*, as they relate to an induction motor and, in Part (b), to list four machines or tools in which single-phase induction motors are used. In response to Part (a) (i), it was found that many candidates could adequately define the term slip, but found it difficult in (ii) to define the term plugging. Most candidates in response to Part (b), correctly listed four machines or tools which use single-phase induction motors.

Question 15

This question tested candidates' knowledge of transformers. Given relevant information on a single-phase transformer, candidates were required to calculate, in Part (a), the number of turns on the primary winding and, in Part (b), the full load primary and secondary currents. For Part (a), many candidates were able to correctly calculate the number of turns on the primary winding of the transformer but in response to Part (b), most candidates were unable to correctly calculate the full load primary and secondary currents.

Paper 02 – Essays

Eighty two candidates wrote this paper. They were required to answer six questions which accounted for 150 marks. Questions 1, 4 and 7 were compulsory and worth 30 marks each. Candidates were required to select one of the remaining two questions in each module which were worth 20 marks each. Most candidates attempted the required two questions from each module. The marks obtained ranged from a low of 2 to a high of 79.

Module 1: AC Circuit Theory (Questions 1 – 3)

Question 1

For Part (a), candidates were required to define the terms *active power* and *apparent power*, provide the formula for calculating each and the units for each term. In Part (b), candidates were required to give two reasons why reactive power is sometimes referred to as imaginary power. In Part (c), candidates were given information on a 60 Hz operated load and they were required to (i) identify the reactive load type, (ii) calculate the reactive power supplied by the addition of parallel capacitors and (iii) calculate the percentage reduction in apparent power. In Part (d), candidates were given a series RLC circuit and were required to draw a labelled phasor diagram to illustrate phasor determination of the total circuit impedance at frequency f, such that the capacitive reactance exceeds the inductive reactance. Part (e) required candidates to draw two cycles of a 1 KHz, 4V peak to peak sinusoidal waveform, and calculate and label (i) the amplitude, (ii) the period and (iii) the r.m.s. value.

In Parts (a) (i) and (ii), candidates correctly defined the terms; however in Part (b), they were unable to explain why reactive power is sometimes referred to as imaginary power. In relation to Part (c), many candidates experienced difficulty identifying the reactive load type and completing the required calculations. Most candidates, in response to Part (d), correctly drew and labelled the phasor diagram and provided the additional information required. For Part (e), most candidates were able to draw the two cycles of the sinusoidal waveform and label them but experienced some difficulty completing the required calculations.

Question 2

This question tested candidates' knowledge of filters. In Part (a), candidates were required to explain the operation of, and sketch and label the frequency response of the following filters: (i) notch, and (ii) high pass. Part (b) required candidates to (i) state the relationship between the 'Q' factor and the bandwidth of a filter, and (ii) determine the edge frequencies F_1 and F_2 given information on an LC circuit at resonance. In Part (c), candidates were required to draw labelled diagrams for a $\boldsymbol{\pi}$

section low pass filter and a π section high pass filter. In Part (d), candidates were given information on a T-section low pass filter and they were required to calculate the nominal impedance and the cut-off frequency.

In response to Part (a) (i), most candidates were unable to explain the operation of the notch filter and were also unable to sketch and label the frequency response. However, the majority of candidates was able to explain the operation of the high pass filter and sketch and label the frequency response. Most candidates responded adequately to Parts (b) (i) and (ii). In response to Part (c), many candidates were able to draw and label the required diagrams, however, the majority of candidates was unable to complete the calculations required for Parts (d) (i) and (ii).

Question 3

Part (a) required candidates to explain the following terms as applied to electrical circuits: (i) *resonance* and (ii) *selectivity*. For Part (b), candidates were given a series RLC circuit with relevant component values and were required to (i) sketch one graph each to show variations of current magnitude with frequency and phase with frequency; (ii) calculate the resonant frequency; (iii) calculate the voltage across the capacitor at the resonant frequency; (iv) determine the 'Q' factor of the circuit; and (v) determine the bandwidth of the circuit. In Part (c), candidates were required to explain why a series RLC circuit at resonance is referred to as an acceptor circuit.

For Parts (a) (i) and (ii), candidates were unable to clearly explain the terms. Most candidates experienced difficulty when attempting Parts (b) (i), (ii), (iii) and (v) due to an inability to complete the calculations needed to answer each sub-part. Part (b) (iv) was widely known by the candidates who used the correct formula and were able to correctly determine the 'Q' factor of the circuit. Part (c) was widely known by candidates; they were able to state why the RLC circuit at resonance is referred to as an acceptor circuit.

Module 2: Digital Electronics & Data Communications (Questions 4 – 6)

Question 4

For Part (a), candidates were required to explain one limitation of thyristor operation and for Part (b), they were asked to explain the terms *holding current* and *latching current* as they relate to a thyristor. In Part (c), candidates were required to use a drawing to show the two-transistor analogy of a thyristor and to explain what is meant by *break over voltage*. Part (d) required candidates to state the typical range of values for the input resistance of a MOSFET while Part (e) asked them to state four advantages of using an enhancement mode MOSFET in digital circuits. Part (f) required an explanation of the concept of the *inversion layer* for an enhanced type

MOSFET and for Part (g), candidates were required to state three characteristics of an ideal switch. In Part (h), candidates were given a figure of a transistor connected in the common emitter configuration and they were required to use a load line drawing to explain how the transistor can be used as a switch to control large load currents.

Candidates found this question to be very challenging. Most were capable of answering Parts (b), (e) and (g) as the topics appeared to be well known. In response to Parts (c), (d), (f) and (h), most candidates experienced much difficulty presenting the required information, thus indicating that they had limited knowledge of the MOSFET, the two transistor analogy of a thyristor, and the transistor as a switch to control large load currents.

Question 5

In Part (a), candidates were required to define the terms *channel capacity* and *bandwidth*. Part (b) required candidates to give one possible reason why errors occur in the signal received in a data communication system and to state how they can be detected and corrected. In Part (c), candidates were given a block diagram of a universal asynchronous receiver transmitter (UART), and they were required to use it to explain the basic operation of a UART. Part (d) required candidates to identify two types of noise found in amplifiers used in communication systems and state two sources of each type of noise identified. In Part (e), candidates were asked to explain the term *differential phase shift keying* as it relates to modulation techniques.

Many candidates demonstrated good knowledge of Parts (a) and (c), providing the required definitions and explaining the general operation of the UART respectively. Parts (b), (d) and (e) posed the greatest challenges; many responses were found to be vague. The purpose of *error detection* and *error correction* were not correctly explained as required for Part (b). Some candidates were able to identify two types and sources of noise for Part (d) but could not explain the term *Differential Phase Shift Keying* required for Part (e).

Question 6

In Part (a), candidates were given a block diagram of a three-stage shift register and were required to outline the operation of the three stages. Part (b) required a sketch of a block diagram of a J–K flip flop and the development of its truth table. Part (c) asked candidates to outline two features of multivibrators while Part (d) asked candidates to explain the operation of a bistable multivibrator. In Part (e), candidates were given a diagram of a 555 timer used in the monostable mode, and they were required to (i) calculate the minimum trigger voltage that would produce an output pulse and the width of the output pulse, and (ii) state the name often given to the 555 timer when it is operating in the monostable mode and indicate why it is given that name. The responses of most candidates to Parts (a) and (b) indicated that they had acquired some knowledge of the information requested but not enough to accurately respond to these parts of the question. Parts (c), (d) and (e) created challenges for most of the candidates; they demonstrated limited knowledge of multivibrators.

Module 3: Introduction to AC Machines (Questions 7 – 9)

Question 7

This question tested candidates' knowledge of transformers. In Part (a), candidates were required to identify the losses which occur in a transformer when loaded. Part (b) required candidates to draw and label a phasor diagram for a single-phase loaded transformer that has negligible voltage drop in its windings. In Part (c), candidates were required to state the condition that must be met in order to achieve maximum efficiency in a transformer. In Part (d), candidates were told that the primary winding of a transformer is connected to a sinusoidal voltage; they were required to sketch and label a typical waveform of flux variation with time in the transformer. Part (e) required candidates to state why there is a no-load current in a transformer. In Part (f), candidates were given specifications for a transformer and were required to calculate (i) the equivalent impedance of the primary and (ii) the voltage regulation and secondary voltage at full load with a power factor of 0.8 lagging.

It appears that this question was quite challenging for most candidates. Most of them were able to provide correct answers for Parts (a) and (b) but experienced some difficulty answering Parts (c), (d) and (e). Parts (f) (i) and (ii) were not well done due to candidates' inability to complete the required calculations.

Question 8

For Part (a), candidates were required to state four reasons why synchronous machines are constructed with stationary armature and rotating field poles. In Part (b), they were required to explain the synchronous impedance voltage drop of a synchronous motor. Part (c) required the use of a labelled graph of an AC generator to explain what is meant by *percentage voltage regulation*. In Part (d), candidates were required to (i) draw a labelled diagram of the equivalent circuit of a synchronous generator and (ii) state what each element represents on the diagram drawn in (d) (i) as well as state how the synchronous impedance can be derived. Part (e) required candidates to state the formula used to calculate the synchronous impedance of the generator.

Most candidates experienced difficulty answering this question. The majority of candidates who attempted Parts (a), (b) and (c) demonstrated some knowledge of the requirements of these parts but Parts (d) and (e) created much difficulty for most of the candidates; they could not adequately answer these two parts of the question due to limited knowledge.

<u>Question 9</u>

Candidates were required, in Part (a), to describe the construction of a squirrel-cage induction motor. In Part (b), candidates were required to use a diagram to assist with describing the operation of a single-phase capacitor run induction motor which incorporates a centrifugal switch. Part (c) required candidates to state six general features of the split-phase capacitor run induction motor. In Part (d), candidates were given a figure showing the torque slip curves for an induction motor; they were required to state the relationship between torque and motor resistance when the resistance is (i) small compared to motor reactance and (ii) large compared to motor reactance.

Most candidates provided adequate answers for Parts (a) and (c) which indicated knowledge of induction motors. Parts (b) and (d) (i) and (ii) were more challenging for most candidates. Candidates could not provide the diagram required for Part (b) and most also could not provide the required answers for Parts (d) (i) and (ii). Their answers indicated that they had limited knowledge of the information required, and therefore, were unable to accurately state the relationship between torque and motor resistance in the two situations given.

Paper 03 – School-Based Assessment (SBA)

<u>Samples Submitted by Schools</u>

Adequate numbers of SBA samples were submitted for inspection and moderation.

The following were observed.

- The grades submitted from some of the schools appeared inflated.
- All students did not adhere to the specific guidelines/requirements for completing SBAs.
- Students need to follow the format established for writing reports.
- There is need to address sentence construction and spelling in the project documentation.
- Students need more guidance in documenting their methodology. Most observed were unacceptable.
- In many instances, candidates failed to adequately discuss the findings of the experiment or outcome of the project.
- Some projects submitted were too simple for the CAPE level.

Recommendations

1. An SBA workshop should be held for schools.
2. Students could benefit from closer supervision.
3. Each student should complete his/her SBA individually.