



# basic education

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

**NATIONAL  
SENIOR CERTIFICATE**

**GRADE 12**

**ELECTRICAL TECHNOLOGY: ELECTRONICS**

**EXEMPLAR 2018**

**MARKING GUIDELINES**

**MARKS: 200**

**These marking guidelines consist of 13 pages.**

## INSTRUCTIONS TO THE MARKERS

1. All questions with multiple answers imply that any relevant, acceptable answer should be considered.
2. Calculations
  - 2.1 All calculations must show the formulae.
  - 2.2 Substitution of values must be done correctly.
  - 2.3 All answers **MUST** contain the correct unit to be considered.
  - 2.4 Alternative methods must be considered, provided that the correct answer is obtained.
  - 2.5 Where an incorrect answer could be carried over to the next step, the first answer will be deemed incorrect. However, should the incorrect answer be carried over correctly, the marker has to re-calculate the values, using the incorrect answer from the first calculation. If correctly used, the candidate should receive the full marks for subsequent calculations.
  - 2.6 Markers should consider that candidates' answers may deviate slightly from the marking guidelines, depending on how and where in the calculation rounding off was used.
3. These marking guidelines are only a guide with model answers. Alternative interpretations must be considered and marked on merit. However, this principle should be applied consistently throughout the marking session at ALL marking centres.

**QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY (GENERIC)**

- 1.1 Workplace is any premises or place where a person performs work ✓ in the course of his employment. ✓ (2)
- 1.2 To cooperate with employer or persons to ensure that any duty given by the employer to the employee shall be performed or compiled in accordance with requirements and procedures. ✓  
To take reasonable care of health and safety for himself and other persons who may be affected by his act. ✓ (2)
- 1.3 Dangerous fumes can accumulate ✓ in the workshop that can be inhaled by people making it an unsafe condition. ✓ (2)
- 1.4 To review the effectiveness of health and safety measures. ✓  
To identify hazards and potential major incidents at the workplace. ✓ (2)
- 1.5 Quantitative risk analysis is an attempt to numerically ✓ determine the probabilities of various adverse events and the likely extent of the losses if a particular event takes place. ✓ (2)
- [10]**

**QUESTION 2: RLC CIRCUITS (GENERIC)**

- 2.1 2.1.1 The current and voltage are in phase ✓ and their phase angle is zero ✓ (2)
- 2.1.2 The current and the voltage are out of phase with each other ✓ and the current is leading the voltage by 90° ✓ (2)
- 2.1.3 The current and the voltage are out of phase with each other ✓ and the current is lagging the voltage by 90° ✓ (2)
- 2.2 2.2.1  $X_L = 2 \pi f L$  ✓  
 $= 2 \times \pi \times 60 \times 30 \times 10^{-3}$  ✓  
 $= 11,31 \Omega$  ✓ (3)
- 2.2.2  $X_C = \frac{1}{2 \pi f C}$  ✓  
 $= \frac{1}{2 \times \pi \times 60 \times 150 \times 10^{-6}}$  ✓  
 $= 17,68 \Omega$  ✓ (3)
- 2.2.3  $Z = \sqrt{R^2 + (X_C - X_L)^2}$  ✓  
 $= \sqrt{12^2 + (17,68 - 11,31)^2}$  ✓  
 $= 13,59 \Omega$  ✓ (3)

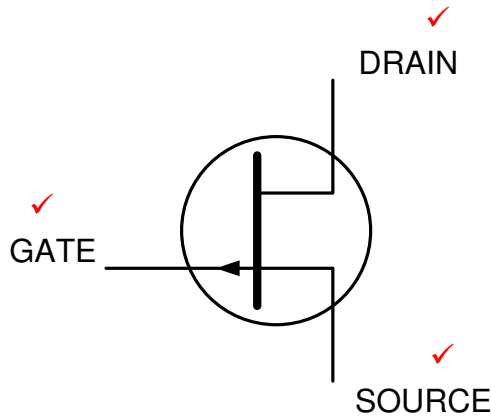
- 2.2.4  $I_T = \frac{V_S}{Z}$  ✓  
 $= \frac{120}{13,59}$  ✓  
 $= 8,83 \text{ A}$  ✓ (3)
- 2.2.5 Power factor  
 $\text{Cos } \theta = \frac{R}{Z}$  ✓  
 $= \frac{12}{13,59}$  ✓  
 $= 0,88$  ✓ (3)
- 2.2.6 The phase angle is leading. ✓ (1)
- 2.3 2.3.1 (a) When the frequency of the supply increases, the inductive reactance ( $X_L$ ) will increase ✓ because the supply frequency is directly proportional ✓ to the inductive reactance. (2)
- (b) When the frequency of the supply increases, the inductive reactance will decrease ✓ because the supply frequency is indirectly proportional ✓ to the capacitive reactance. (2)
- 2.3.2 The resistance of a resistor is not affected by the increase ✓ or decrease of the frequency of the supply voltage. ✓ (2)
- 2.3.3 Z or Impedance ✓ (1)
- 2.4 2.4.1  $F_r = \frac{1}{2\pi\sqrt{LC}}$  ✓  
 $= \frac{1}{2\pi\sqrt{30 \times 10^{-3} \times 120 \times 10^{-6}}}$  ✓  
 $= 83,88 \text{ Hz}$  ✓ (3)
- 2.4.2 Q – factor =  $\frac{X_L}{R}$  ✓  
 $X_L = 2 \times \pi \times f \times L$  ✓  
 $= 2 \times \pi \times 83,88 \times 30 \times 10^{-3}$  ✓  
 $= 15,81 \Omega$  ✓  
 $\therefore \text{Q - factor} = \frac{15,81}{10}$  ✓  
 $= 1,58$  ✓ (5)
- 2.4.3  $BW = \frac{F_r}{Q}$  ✓  
 $= \frac{83,88 \text{ Hz}}{1,58}$  ✓  
 $= 53,09 \text{ Hz}$  ✓ (3)

(3)  
[40]

**QUESTION 3: SEMICONDUCTOR DEVICES (SPECIFIC)**

3.1 The JFET is a voltage-controlled device. ✓ (1)

3.2



(3)

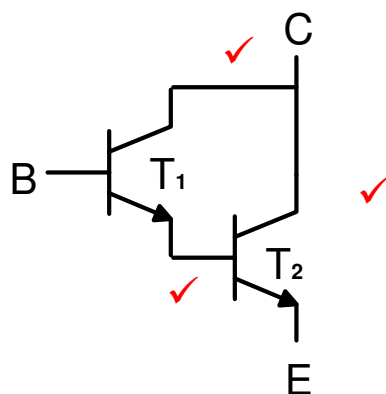
3.3 If  $V_{GS}$  is increased, the depletion layer between the N-channel and the gate will widen. ✓ This widened depletion layer will make the N-channel narrower ✓ thus decreasing the  $I_{DS}$  current. ✓ (3)

3.4 MOSFET (metal-oxide-silicon field-effect transistor) ✓✓ (1)

3.5 If  $V_{GS}$  exceeds 0 V, the MOSFET operates in the enhancement mode. ✓ (1)

3.6 The UJT can be used as a  
Switch ✓  
Saw-tooth generator ✓ (2)

3.7 Darlington pair transistor.



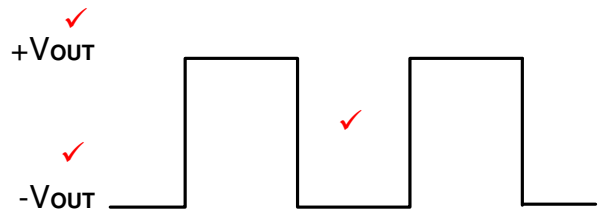
(3)

- 3.8 3.8.1 A - Non-inverting input✓  
B - Inverting input✓ (2)
- 3.8.2 It is important for the op-amp to have a dual voltage supply to be able to amplify all signals above 0 V✓ and below 0 V✓ (positive and negative signals) (2)
- 3.9 3.9.1  $A_V = -\frac{R_F}{R_{IN}}$  ✓  
 $= -\frac{2000}{220}$  ✓  
 $= -9,09$  ✓ (3)
- 3.9.2  $V_{OUT} = V_{IN} \times \left(-\frac{R_F}{R_{IN}}\right)$  ✓  
 $= 0,55 \times \left(-\frac{2000}{220}\right)$  ✓  
 $= -5 V$  ✓ (3)
- 3.9.3 If the value of the feedback resistor is increased to 20 kΩ the gain of the amplifier will increase to -90,9✓ and the output voltage will increase to -50 V. ✓✓ (2)
- 3.10 Timing functions (turning a light on and off for a prescribed time) ✓  
Creating a warning light✓  
Pulse, oscillation and signal generation  
Digital logic probes  
Controlling the positioning of a servo device  
ANY TWO relevant answers (2)
- 3.11 Pin 6 (threshold) sets the voltage✓ at which the 555 IC will trigger. ✓ (2)

**[30]**

**QUESTION 4: SWITCHING CIRCUITS**

4.1



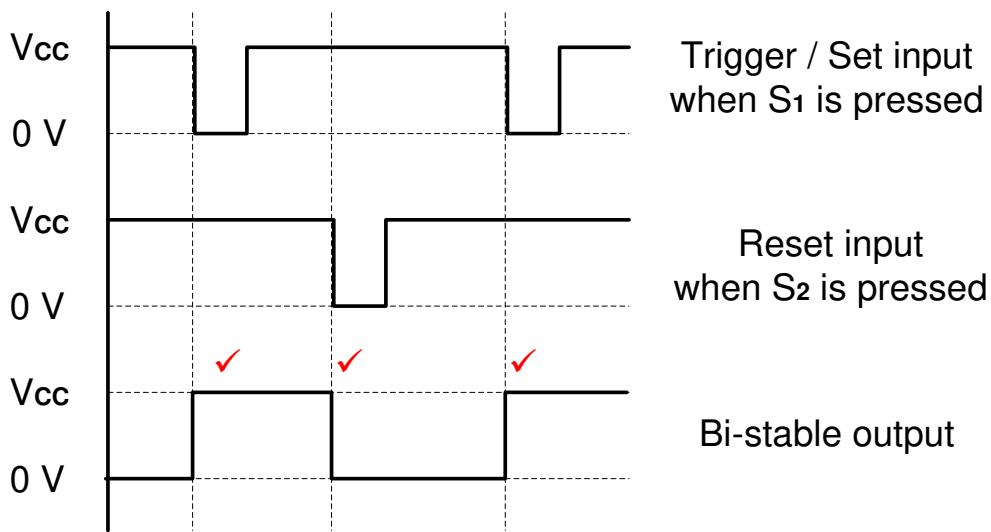
(3)

4.2

The bi-stable multivibrator is defined as a circuit that is able to give and hold two stable output values, ✓ either high or low ✓ whenever a trigger pulse is received. ✓

(3)

4.3



(3)

4.4

4.4.1 Contact debouncer ✓

(1)

4.4.2  $R_1$  is necessary to prevent pins 6 and 7 ✓ from being directly connected to the positive voltage supply ✓ when  $V_{R_1}$  is set to  $0 \Omega$ . ✓

(3)

4.4.3 An increase of  $C_1$  will increase the RC time constant ✓ of the circuit keeping the output at a 'high' or 'on' state for longer. ✓

(2)

4.4.4 When  $S_1$  is pressed, the input voltage on pin 2 will be pulled down to  $0 V$ . ✓ This triggers the 555 IC ✓ setting the output voltage at pin 3 and pin 7 to high. ✓ Once the capacitor voltage  $V_{C_1}$  reaches  $2/3$  of the supply voltage ✓, it will immediately trip the internal timing circuit to reset the output pin 3 to low or  $0 V$  returning to its stable state. ✓

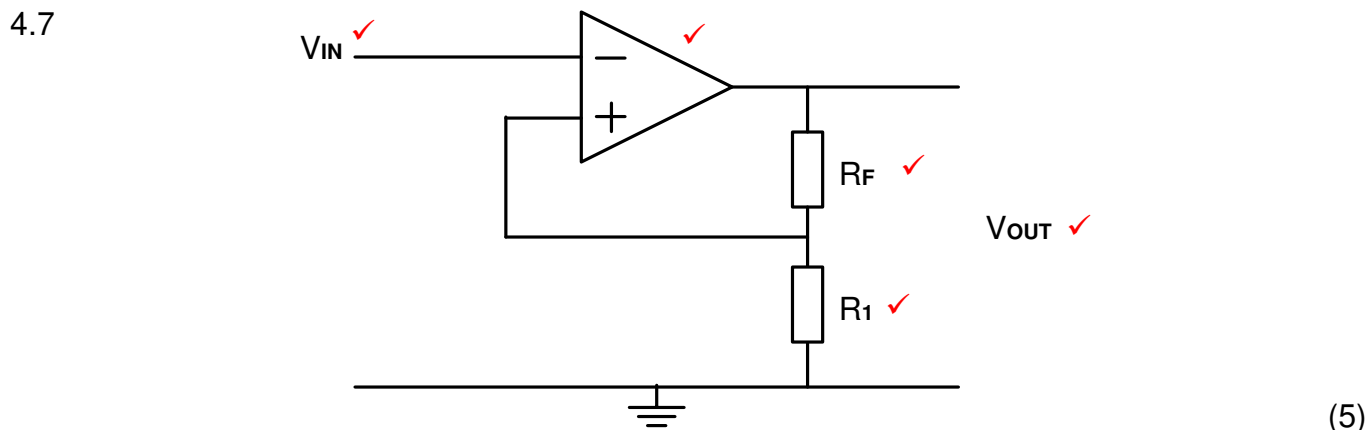
(5)

4.5

Radio receiver filters ✓  
 Contact de-bouncer ✓  
 Analogue to digital converter  
 Signal recovering

(2)

- 4.6 The Schmitt trigger is able to trigger at TWO different voltages. ✓ The moment the input rises above the upper trigger level its output will go to negative saturation ✓ and the moment the input falls below the lower trigger level its output will go to positive saturation. ✓ (3)



- 4.8 4.8.1 Resistor  $R_2$  determines the reference voltage of the comparator ✓ (1)

- 4.8.2 Resistors  $R_1$  and  $R_2$  creates a voltage divider ✓ that feeds a reference voltage into the non-inverting input ✓ while its inverting input is usually fed by a transducer. ✓ These two voltages are compared and as soon as the voltage on the inverting input goes higher than the non-inverting input ✓ the amplifiers output will go into negative saturation. ✓ The moment the non-inverting voltage goes higher than the inverting voltage the amplifiers output will go into positive saturation. ✓ (6)

- 4.8.3 To adjust the reference voltage the, resistor  $R_2$  can be replaced by a variable resistor ✓ (1)

- 4.9 4.9.1 Inverting ✓ summing amplifier ✓ (2)

- 4.9.2 Negative feedback ✓ (1)

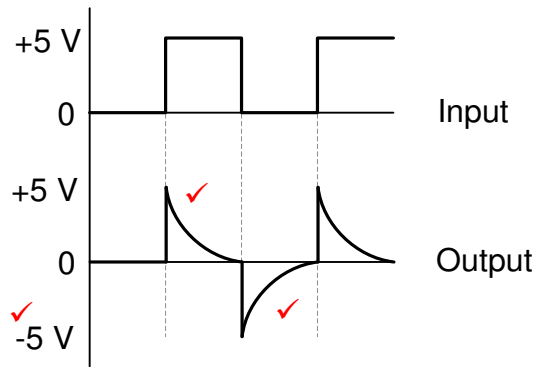
- 4.9.3 The gain of the amplifier is determined by the ratio of the feedback resistor ✓ to the input resistance ✓ of each branch. ✓ (3)

- 4.9.4  $V_{OUT} = -(V_1 + V_2 + V_3)$  ✓  
 $V_{OUT} = -(850 \text{ mV} + 200 \text{ mV} + 950 \text{ mV})$  ✓  
 $V_{OUT} = -2 \text{ V}$  ✓ (3)

- 4.10 The function of a differentiator is to change a square wave ✓ into a triangular wave. ✓ (2)



4.11 4.11.1



(3)

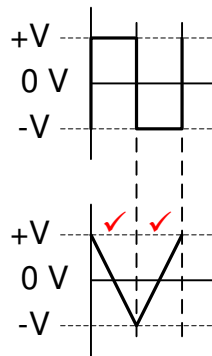
4.11.2 A long time constant will cause the capacitor to discharge slower/ causing the output signal to become more like a distorted square wave./

(2)

4.12 4.12.1 Inverting/ integrator

(2)

4.12.2



(2)

4.12.3 The higher the frequency for a particular time constant, the better the shape,/ but the smaller its amplitude./

(2)  
[60]

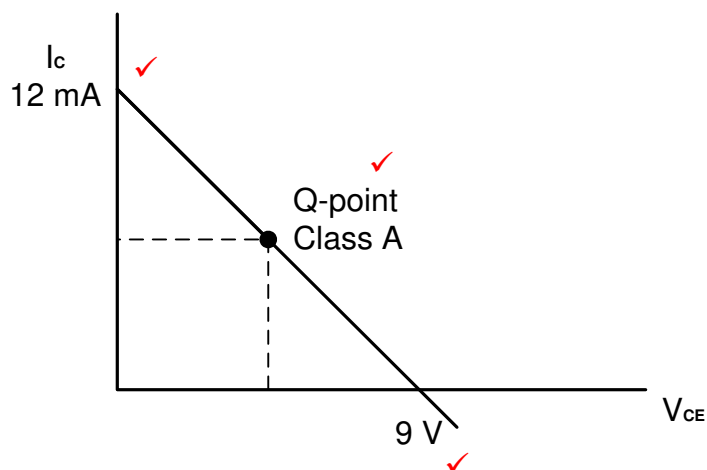
**QUESTION 5: AMPLIFIERS**

5.1 Class B amplification is when the output collector current of the amplifier flows for only 180° of the input cycle. ✓ (2)

5.2 5.2.1  $V_{CC} = V_{CE} + I_C R_C$   
 $V_{CC} = V_{CE}$  ✓ when the transistor is OFF and collector current is not flowing  
 $V_{CE} = 9\text{ V}$  ✓ When the transistor is biased, the collector current will flow (2)

5.2.2  $I_C = \frac{V_C}{R_C}$  ✓  
 $= \frac{9}{750}$  ✓  
 $= 12\text{ mA}$  ✓ (3)

5.2.3



5.2.4 If the load resistance increases the value of the collector current decrease. ✓ (1)

5.3 If the supply voltage increases, collector current will increase ✓ and the quiescent point will move up the load line towards saturation. ✓ (2)

5.4 5.4.1 Is to enable each stage to individually maintain its own DC biasing ✓ levels without interference from any of its neighbouring stages. ✓  
 Allows the transfer of the alternating signal voltage between stages for amplification. (2)

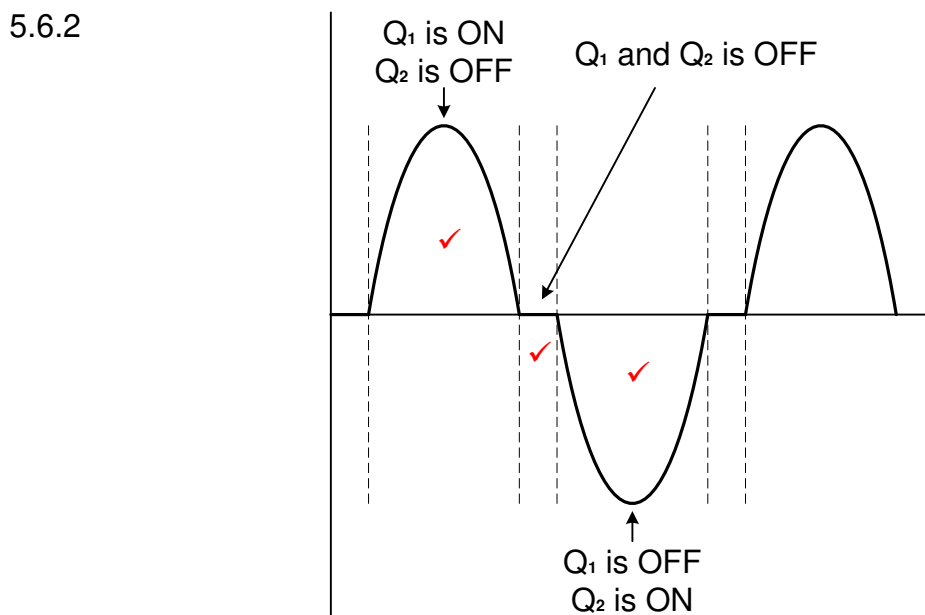
5.4.2  $A = \beta_1 \times \beta_2$  ✓ (1)

5.4.3 As the frequency rises the amplification will decrease ✓ due to parasitic capacitance which develop inside the transistor, ✓ their reactances will become lower and would cause upper frequency roll off. ✓ (3)

5.5 5.5.1 Poor frequency response✓  
Large and heavy✓  
Expensive components (2)

5.5.2 If the loudspeaker is changed to a lower impedance loudspeaker, a matching transformer✓ must be chosen to drive the speaker✓ to ensure maximum power transfer.✓ (3)

5.6 5.6.1 When the dc base voltage drops to zero, transistors Q1 and Q2 are OFF.✓ The input signal must pass through the region where both transistors are not conducting,✓ this will cause cross-over distortion. (2)



(3)

5.6.3

$$P_o = I^2 \times Z_o$$

$$I = \sqrt{\frac{P_{out}}{Z_{out}}} \quad \checkmark$$

$$= \sqrt{\frac{100}{20}} \quad \checkmark$$

$$= 2,24 \text{ A} \quad \checkmark$$

$$A_i = 20 \log \frac{I_o}{I_i} \quad \checkmark$$

$$= 20 \log \frac{2,24}{200 \times 10^{-3}} \quad \checkmark$$

$$= 20,97 \text{ dB} \quad \checkmark$$

(6)

- 5.7 5.7.1 A radio-frequency amplifier amplifies a single high frequency✓ usually above 100 kHz and suppresses all other frequencies.✓ (2)
- 5.7.2 Capacitor  $C_1$  and the primary turns of second transformer ( $T_2$ ) forms the tuning circuit which resonate at the required frequency✓ and passes the resonating frequency to the second LC tuned circuit formed by  $C_2$  and secondary turns of  $T_2$ ✓ which makes it more selective. ✓ (3)
- 5.7.3 By varying capacitors  $C_1$  and  $C_2$ , ✓ the tuned circuit will resonate at different frequencies✓ therefore passes a range of frequencies.✓ (3)
- 5.8 5.8.1 The RF coil offers resistance (reactance) against the change in the collector current ✓and causes the collector voltage  $V_C$  to decrease. ✓ (2)
- 5.8.2 The tank circuit receives energy from a dc source and convert that energy into a sinusoidal signal✓ at a frequency determined by the inductor and capacitor.✓ (2)
- 5.8.3
- 
- (2)
- 5.8.4 Hartley oscillator - tank circuit consists of two inductors and one capacitor. ✓  
Colpitts oscillator - tank circuit consists of two capacitors and one inductor✓ (2)
- 5.9 5.9.1 The RC network will determine the frequency of oscillation✓ and causes a phase shift of  $180^\circ$ . ✓ (2)
- 5.9.2 Positive feedback✓ occurs when a portion of the output✓ signal is fed back in phase with the input signal.✓ (3)
- 5.9.3 Phase shift around the feedback loop must be 0 degrees✓  
The voltage gain around the feedback loop must be 1✓ (2)
- 5.9.4 The FET minimizes the loading effect when compared to the BJT due to its higher input impedance.✓ This stabilizes the resonating frequency. ✓ (2)

**[60]****TOTAL: 200**