basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

ELECTRICAL TECHNOLOGY

NOVEMBER 2017

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 17 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 learner answers may deviate slightly from the guideline, depending on how and where in the calculation rounding off was used.

3. This memorandum is 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

1.1   1.1.1   Operating a machine or equipment without authorisation ✓
                   Failing to switch and lockout power when servicing a machine
                   Bypassing or removing safety guards
                   Wearing unsafe clothing or protective clothing
                   Playing around in the workshop
                   Using defective or faulty equipment   (1)

           1.1.2   Inadequate guarding of machines✓
                   Overcrowding in the workshop
                     Inadequate warning system
                   Excessive noise
                   Poor ventilation
                   Poor house keeping
                   Insufficient lighting   (1)

1.2   Each member of the team will be given responsibility✓
       Team members help each other to work honestly✓
       Team members help each other to work safely✓
       Team members help each other to work efficiently
       Team work contributes towards the advancement of the team's goal.   (3)

1.3   Identify and apply pressure on✓ the pressure point next to the bleeding area✓
       Lift and keep the bleeding area above the heart level
       Use a clean sterile bandage to dress the bleeding area   (2)

1.4   Any form of drug-abuse has the potential to reduce the ability✓ of an employee to work safely and cautiously ✓and these may lead to the amount of production been reduced or rejected due to substandard work. ✓   (3)
   **[10]**

QUESTION 2: THREE-PHASE AC GENERATION

2.1   Neutral point is available when connected in star for distribution to consumers, ✓ allowing for both phase and line voltage (Two voltages are available)
Load distribution and phase balancing become possible ✓
Three phase supply systems are more versatile because they can be operated in star or in delta. ✓

Note to marker:
When listing advantages of a three phase motor, this will be deemed incorrect.   (3)

2.2
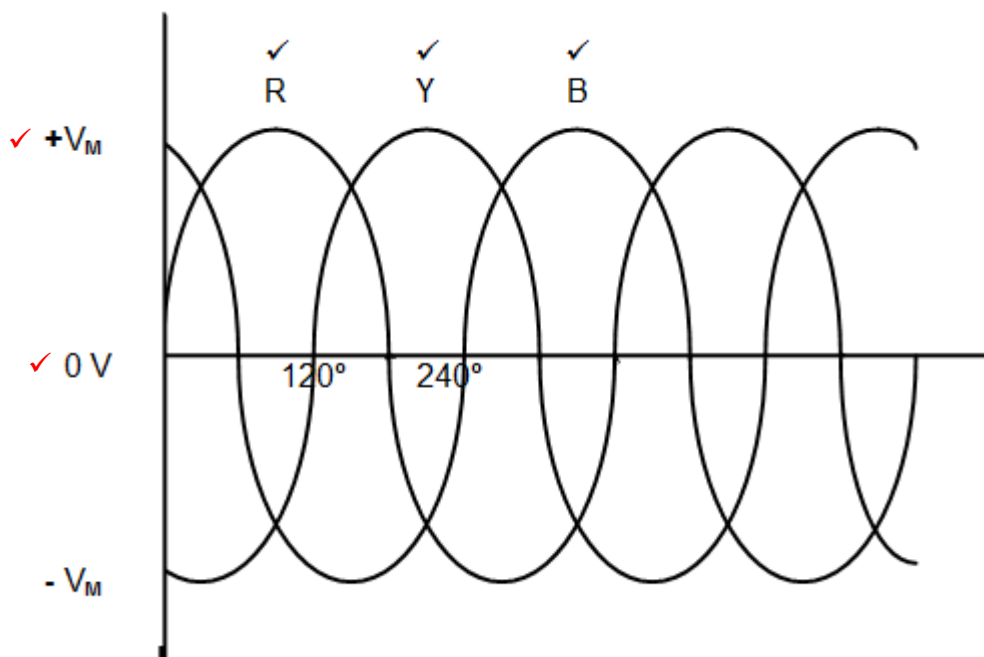
Note: Alternative correct labelling should be considered and marked on merit.
Correctly labelled phasor diagrams are acceptable.   (5)

2.3   The two wattmeter method cannot determine if the power factor is leading or lagging.✓   (1)

2.4   2.4.1 $S = \sqrt{3}V_L I_L$

$V_L = \dfrac{S}{\sqrt{3} \times I_L}$ ✓

$= \dfrac{25 \times 10^3}{\sqrt{3} \times 38}$ ✓

$= 379{,}84 \text{ V}$ ✓   (3)

2.4.2 $V_L = \sqrt{3} \times V_{PH}$

$V_{PH} = \dfrac{V_L}{\sqrt{3}}$ ✓

$V_{PH} = \dfrac{379.84}{\sqrt{3}}$ ✓

$= 219{,}31\text{V}$ ✓

(3)

2.4.3 $Z_{PH} = \dfrac{V_{PH}}{I_{PH}}$ ✓

$= \dfrac{219.31}{38}$ ✓

$= 5{,}77\,\Omega$ ✓ (3)

2.5 An improved power factor will lead to less wasted energy✓ thus leaving more power available to consumers. ✓
Power is utilised more effectively thus reducing generation cost.
Eskom will have more power available to supply consumers; with the improved power factors, there will be more power available on the national grid.

(2)
[20]

QUESTION 3: THREE-PHASE TRANSFORMERS

3.1 The purpose of a transformer is to step down✓ or step up an alternating voltage. ✓
To transfer power from one ac circuit to another, with a change of voltage and corresponding current flow.
To isolate one circuit from another electrically. (2)

3.2 Copper losses ✓
I^2R losses (1)

3.3 Air cooling ✓
Oil filled self-cooling ✓
Oil filled water cooling (2)

3.4 The transformer will overheat, ✓ the insulation between the windings will be damaged depending on the degree of heat✓ and in extreme cases this will lead to internal short circuit. ✓
Gas forming can occur which is in turn is highly combustible (3)

3.5 Used to distribute power to consumers✓ in the substation
It provides a neutral point to the four core end user system. ✓
To step down the voltage to a 380 V three-phase and 220 V single phase supply. (2)

3.6   3.6.1

$$S = \sqrt{3}V_L I_L \quad ✓$$

$$I_{L2} = \frac{S}{\sqrt{3}V_L}$$

$$= \frac{120000}{\sqrt{3} \times 380} \quad ✓$$

$$= 182,32\,A \quad ✓$$

(3)

3.6.2 $I_{PH} = I_L \quad ✓$

$= 182,32\,A \quad ✓$ (2)

3.6.3

$$P = \sqrt{3}V_L I_L \cos\theta \quad ✓$$

$$= \sqrt{3} \times 380 \times 182.32 \times 0.9 \quad ✓$$

$$= 107999,32\,W$$

$$= 108\,kW \quad ✓$$

(3)

Note: P=S x Cos θ is also correct

3.7   The secondary winding of a step down transformer has a thicker wire that will accommodate ✓ a higher current ✓ in the secondary.   (2)

[20]

QUESTION 4: THREE-PHASE MOTORS AND STARTERS

4.1   4.1.1   Stator ✓
Squirrel cage rotor ✓
Windings
Field Poles   (2)

4.1.2   The connection to any TWO ✓ of the windings must be swapped. ✓   (2)

4.1.3   Delta connection will develop the greater torque. ✓
In delta the full line voltage will be connected across each winding. ✓
This increased voltage will give rise to an increased current.✓
This increased current will create stronger magnetic fields therefore leading to a greater output torque. ✓   (4)

4.2   A Three-phase induction motor requires less maintenance as it does not have as many parts as a single phase motor.✓
For the same size frame as a single phase motor it delivers higher torque.   (1)

4.3   4.3.1   The resistive reading of the W winding is not close to the readings on the other two windings suggesting a fault.✓ Due to the high value the winding could indicate an open circuit / loose connection in that winding. ✓   (2)

4.3.2 A 0 Ω reading would indicate a short circuit✓ between earth and the winding. ✓ (2)

4.3.3 The megger (insulation resistance tester) must be set to the 1 000 V setting ✓
One lead must be connected to one of the windings and the other lead to the other winding. ✓
The reading must be taken and the test repeated between all three windings (2)

4.4 4.4.1 $n_R = n_S(1-S)$ ✓
✓
$n_R = 1500(1-0,06)$
$n_R = 1410 \text{ r/min}$ ✓ (3)

4.4.2 The frequency determines the speed✓ at which the motor will run✓
If the frequency of the supply changes the speed of the motor will change.
A change in speed of the motor will affect the load speed which could be detrimental to the load✓ (3)

4.5 4.5.1 $S = \dfrac{P_{OUT}}{\eta \times \cos\theta}$ ✓

$= \dfrac{6800}{0,95 \times 0,8}$ ✓

$= 8947,36 \text{ VA}$

$= 8,95 \text{ kVA}$ ✓ (3)

4.5.2 $\cos\theta = 0,8$
$\theta = \cos^{-1}0,8$ ✓
$= 36,87°$ ✓

$Q = S \times \sin\theta$
$= 8947,36 \times \sin 36,87$ ✓
$= 8,947 \times 0,6$ ✓
$= 5368,42 \text{ VAr}$
$= 5,37 \text{ kVAr}$ ✓ (5)

4.6 4.6.1 Sewerage pumps ✓
Conveyer belt (1)

4.6.2 Without the start been depressed the timer contactor would be energised✓ starting motor two after the timer has timed through✓ (2)

4.6.3 When the start button is depressed MC_1 is energised starting M_1✓
MC_1 N/O_1 will now close and will hold the circuit in when the start is released ✓
MC_1 N/O_2 will now close energising the timer contactor which will begin the timing process✓
The T N/O will close after a predetermined time, energising MC M_2 contactor switching M_2 on ✓ (4)

4.6.4 The control circuit is designed so that O/L's are connected in series✓ with the contactor coil of each motor's contactor.✓ The two overloads may be set independently ✓which would protect each of the motors independently. ✓ (4)

[40]

QUESTION 5: RLC

5.1 Impedance is the total opposition offered to the flow of current✓ when a RLC circuit is connected across an alternating voltage supply.✓ (2)

5.2 5.2.1 V_L is greater than V_C which will result in a leading reactive voltage✓
The current I_S will lag the voltage V_S. ✓
Therefore the circuit is resistive inductive. ✓ (3)

5.2.2 If the frequency of the supply was increased the inductive reactance X_L of the coil would increase✓ as X_L is directly proportional to the frequency of the supply. ✓
If the inductive reactance of the coil increased the voltage across the coil V_L would increase. ✓ (3)

5.2.3 $$V_T = \sqrt{V_R^2 + (V_L - V_C)^2}$$ ✓
$$= \sqrt{110^2 + (80 - 50)^2}$$ ✓
$$= 114,02 \text{ V}$$ ✓ (3)

5.3 5.3.1 $$I_T = \sqrt{I_R^2 + (I_L - I_C)^2}$$ ✓
$$= \sqrt{5^2 + (6 - 4)^2}$$ ✓
$$= 5,39 \text{ A}$$ ✓ (3)

5.3.2 $$\theta = \cos^{-1} \frac{I_R}{I_T}$$ ✓
$$\theta = \cos^{-1} \frac{5}{5,39}$$ ✓
$$= 21.93°$$ ✓ (3)

5.3.3 $$X_L = \frac{V_T}{I_L}$$ ✓
$$= \frac{240}{6}$$ ✓
$$= 40 \text{ Ω}$$ ✓ (3)

[20]

QUESTION 6: LOGIC
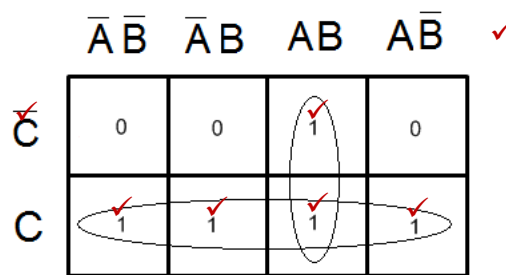
6.1   Reduced space✓
           Use less energy✓
           Less maintenance✓
           More reliable
           Faster response time
           Flexible and
           Economical   (3)

6.2   Ladder diagrams✓
           Function blocks✓
           Sequential function
           Instructional list
           Structured text.   (2)

6.3

$$Q = A\,B + C$$ (10)

Note: Alternative labelling of the Karnaugh Map should be considered, thus influencing the placement and grouping of operands, however, the answer remains intact
Two Marks – Labelling
Five Marks – operands in K-Map
NO Marks for Grouping
One mark per operand in equation
One Mark for function in equation.

6.4

$$F = \left(\overline{A + B}\right)\left(AB\right) + \overline{C}$$

One mark for each operand (AND/OR
One mark for each inverse (not indicator) not sign   (6)

6.5 $Q = \overline{A}\,\overline{B}\,C + \overline{A}\,B\,C + A\,B\,C + A\,\overline{B}\,C$
        $= \overline{A}.C\left(\overline{B} + B\right) + AC\left(B + \overline{B}\right)$
        $= \overline{A}\,C + A\,C$
        $= C\left(\overline{A} + A\right)$ ✓
        $= C$ ✓

Note: If learner arrives at answer in less steps = full marks
If learner only shows the answer, award ONE mark.

        (6)

6.6   6.6.1
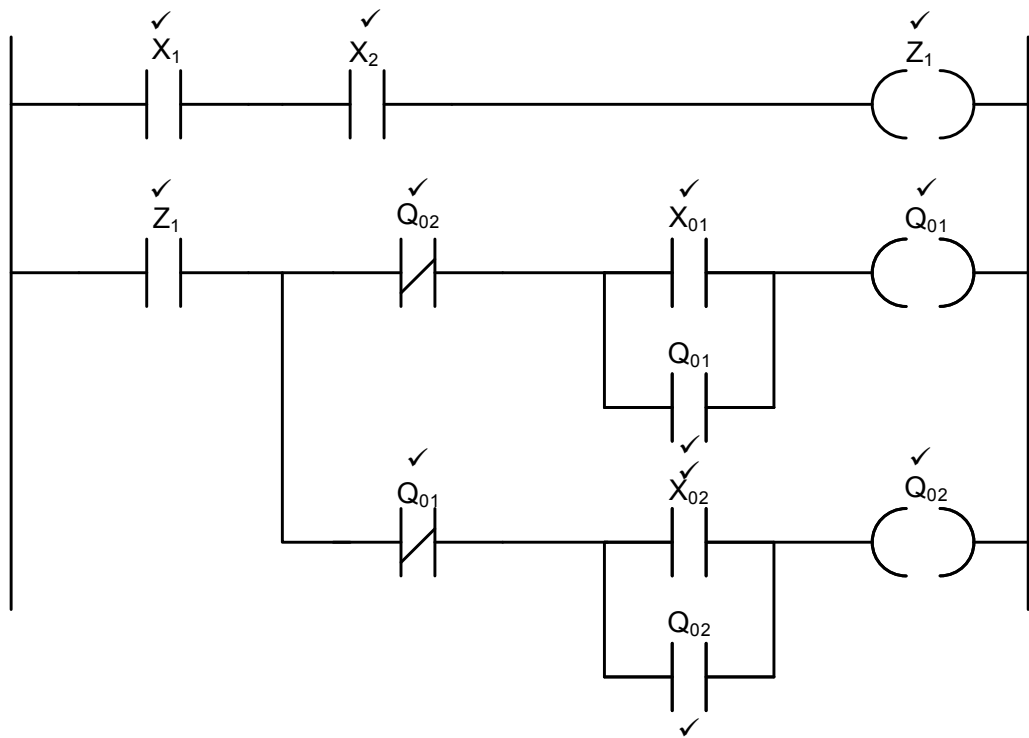
Labels	Description
X_1	O/L
X_2	Stop
Z_1	Marker/flag
Q_{02}	Reverse MC2
Q_{01}	Forward MC1
X_{01}	Start forward
X_{02}	Start reverse

(12)

Alternative ladder diagram
6.6.1

6.6.2   Lifts ✓
        Cranes
        Conveyor belts   (1)
                                                                                  [40]

QUESTION 7: AMPLIFIERS

7.1   An op amp is an integrated circuit✓ of a differential amplifier✓   (2)
       An op amp is an integrated circuit with a high voltage gain which consists of
       many components.
       It is a circuit that has a very high open loop voltage gain.

7.2   Cheap to manufacture✓
       Versatile✓
       Easy to use
       Contain a correctly assembled circuit allowing for fewer external components
       to be used   (2)

7.3   A differential amplifier has two inputs and one output✓. When two inputs are
       supplied to the amplifier, it amplifies only the difference✓ between the two
       inputs✓
       Note: If the learner uses actual values / refers to voltages/inputs and shows
       answer in arithmetic, the answer must be considered.   (3)

7.4   7.4.1   Negative feedback✓   (1)

       7.4.2   Positive feedback✓   (1)

7.5   Positive feedback: A portion of the output signal is fed back to the input✓ in phase with the input signal✓
       Negative feedback: A portion of the output signal is fed back to the input 180º out of phase✓ with the input signal   (3)

7.6   7.6.1

$$V_{out} = \left(1 + \frac{R_f}{R_{in}}\right)V_{in} \qquad ✓$$

$$= \left(1 + \frac{170000}{10000}\right) \times 0,7 \qquad ✓$$

$$= 12,6 \text{ V} \qquad ✓$$

       NOTE: The output is possibly driven to saturation depending on the value of the supply voltage   (3)

       7.6.2

$$A_v = \frac{V_{out}}{V_{in}} \qquad ✓$$

$$= \frac{12,6}{0,7} \qquad ✓$$

$$= 18 \qquad ✓$$ (3)

7.7   Audio amplifiers✓
       Filters ✓
       Oscillators
       Controllers   (2)

7.8   Pulse detector✓
       Contact debouncer   (1)

7.9   Bi-stable multi-vibrator remains in one state (Reset)✓until a new trigger sets it to a different state (Set) where it will remain.   ✓
       The mono-stable multi-vibrator will change state (Set) when triggered✓. It will remain in this state for a set amount of time after which it will return to its original/stable state. (Reset)✓   (4)

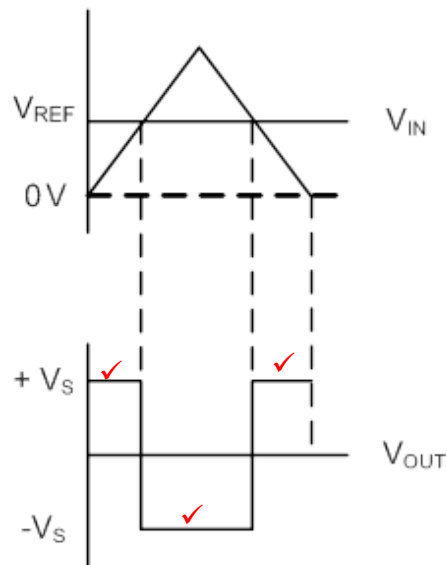7.10   7.10.1

INTEGRATOR OP-AMP
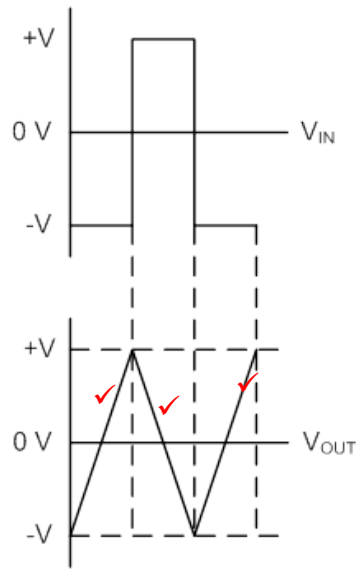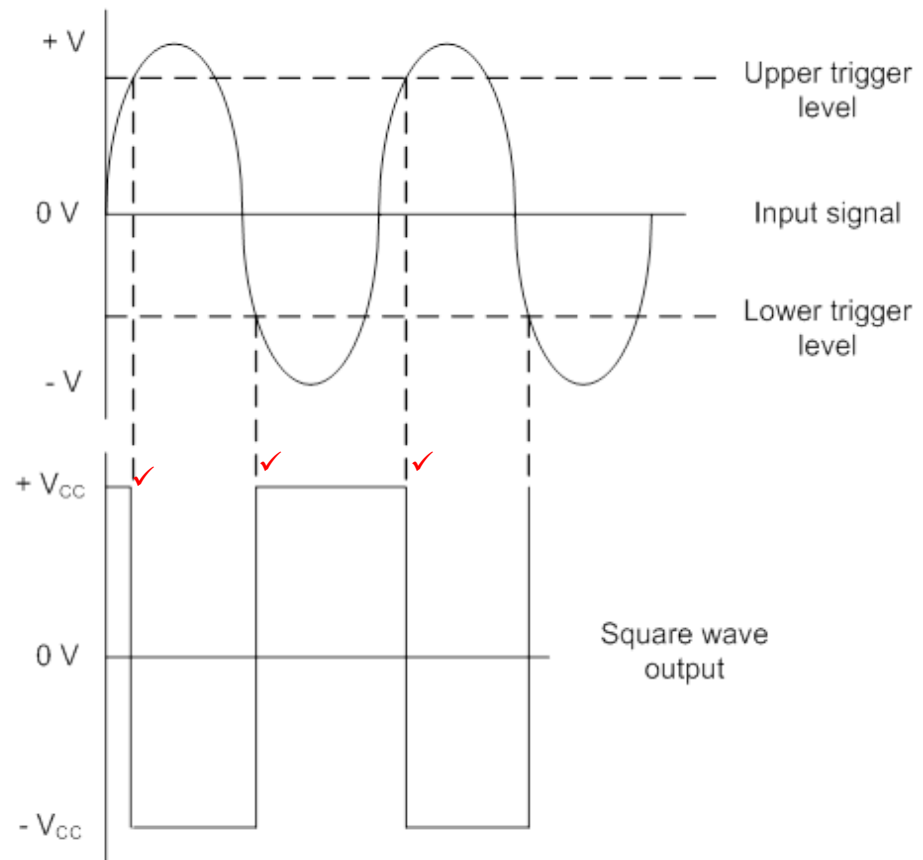

(3)

7.10.2

INVERTING COMPARATOR
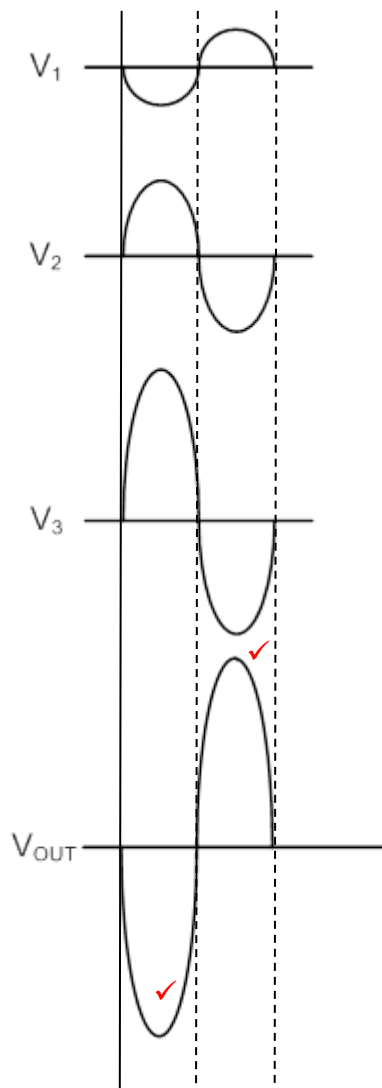

(3)

7.10.3   **INVERTING SCHMIDT TRIGGER OP-AMP**

(3)

Note: If no input is drawn, care must be taken to the proportion and the placement of the output waveform when allocating marks.

7.11

1 Mark awarded for inversion ✓

(3)

7.12   7.12.1

$$V_{out} = -\left(\frac{R_f}{R_{in}}\right)V_{in} \qquad ✓$$

$$= -\left(\frac{200000}{20000}\right) \times 5 \qquad ✓$$

$$= -50 \text{ V} \qquad ✓$$

(3)

7.12.2

$$A_v = -\left(\frac{R_f}{R_{in}}\right) \qquad ✓$$

$$= -\left(\frac{200000}{20000}\right) \qquad ✓$$

$$= -10 \qquad ✓$$

(3)

7.13   To clean noisy signals.✓
        To implement another type of multi-vibrator.
        Interfacing of analogue and digital signals.
        Measuring of frequency in AC circuits.
        Change any waveform into a square wave.   (1)

7.14 $f_r = \dfrac{1}{2\pi\sqrt{LC}}$ ✓

        $= \dfrac{1}{2\times\pi\sqrt{(27\times10^{-3})\times(47\times10^{-6})}}$ ✓

        $= 141{,}28\,\text{Hz}$ ✓   (3)

7.15 $f_r = \dfrac{1}{2\pi RC\sqrt{2\,x\,n}}$ ✓

        $= \dfrac{1}{2\times\pi\times(25\times10^{3})\times(45\times10^{-12})\times\sqrt{2\,x\,3}}$ ✓

        $= 57755{,}32\,\text{Hz}$

        $= 57{,}76\,\text{kHz}$ ✓   (3)
                                                                          [50]

                                                   TOTAL: 200