Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2017

ELECTRICAL TECHNOLOGY

MARKS: **200**

TIME: **3 hours**

IELTTE

This question paper consists of 15 pages, including a 2-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. This question paper consists of 17 questions.

2. Learners offering ELECTRICAL must answer only the following questions.

QUESTION	1	2	3	4	5	6	7	8	9
TICK AFTER ANSWERING									

3. Learners offering ELECTRONICS must answer only the following questions:

QUESTION	1	2	6	10	11	12	13	14	15
TICK AFTER ANSWERING									

4. Learners offering DIGITAL ELECTRONICS must answer only the following questions:

QUESTION	1	2	6	10	11	14	15	16	17
TICK AFTER ANSWERING									

5. Sketches and diagrams must be large, neat and fully labelled.

6. Show ALL calculations and round off answer correctly to TWO decimal places. Show the units for ALL answers of calculations.

7. Number the answers correctly according to the numbering system used in this question paper.

8. You may use a non-programmable calculator.

9. A formula sheet is provided at the end of the question paper.

10. Write neatly and legible.

QUESTION 1: (ELECTRICAL, ELECTRONICS AND DIGITAL) OCCUPATIONAL HEALTH AND SAFETY

1.1 How is it possible to protect workers against injury, from the converging point between two moving parts of a machine? (3)

1.2 Mention ONE of the areas which are covered by the Regulations on Hazardous Work by Children in South Africa (2010). (1)

1.3 Explain how it is possible to ensure that a certain area is set aside and reserved only for one particular task. (2)

[6]

QUESTION 2: (ELECTRICAL, ELECTRONICS AND DIGITAL) TOOLS AND MEASURING INSTRUMENTS

2.1 State ONE safety step to observe when using a power drill. (1)

2.2 Give ANY point one should avoid doing when handling tools in a workshop. (1)

2.3 Explain why the accurate measuring of power factor is essential. (2)

2.4 Why is it important to stand aside to allow the grinder wheel to run up to full speed before using it? (2)

[6]

QUESTION 3: (ELECTRICAL) DC MACHINES

3.1 The resistance of armature circuit of a shunt machine is 0,5 Ω and the armature current is 30 A. The field circuit has a resistance of 50 Ω and the field current 2,5 A. The output power is given as 3,5 kW while the rotational losses are 345 W.

Determine:

3.1.1 The copper losses (5)

3.1.2 The efficiency (3)

3.2 Explain how armature reaction occurs in a DC machine and the effect it has on the flux of the machine. (2)

3.3 Describe in not more than one sentence the general functions of the main components of a DC machine. (2)

3.4 State why is it essential to maintain a DC machine. (2)

3.5 Give THREE methods that are used to improve commutation. (3)

3.6 In your own words, describe the main difference between a generator and motor. (2)

3.7 Describe a voltage drop test done on the field coils. (3)

3.8 An armature has six poles and 480 conductors. Determine the number of conductors per parallel path if it is lap wound. (4)

[26]

QUESTION 4: (ELECTRICAL) SINGLE-PHASE AC GENERATION

4.1 Calculate the voltage generated in a single loop generator with a coil length of 6 cm, turning at a velocity of 80 m/s while the coil turns through a magnetic field strength of 120 mT. (3)

4.2 The average voltage value of a sinusoidal wave is 9,54 volt. Calculate its peak voltage. (3)

4.3 A sine wave has a period of 40 ms. Calculate its frequency. (3)

4.4 Calculate the emf induced in a conductor if it cuts through a magnetic field with a flux density of 1 500 mT in 0,3 seconds. (3)

4.5 Calculate the magnetic flux of a magnetic field if a conductor passed through the field in 0,2 seconds and has an emf of 1,5 volt induced into it. (3)

4.6 Draw a simple two cycle voltage sine wave. Clearly label the following:

4.6.1 Each cycle (2)

4.6.2 The peak voltage (1)

4.6.3 The peak-to-peak voltage (1)

4.7 A constant flux density of 600 T is measure over an area of 1,5 cm^2. Calculate the value of the total flux in this area. (3)

4.8 Calculate the frequency of a four pole AC generator with a rotor turning at 2 400 r.p.m. (2)

4.9 Calculate the voltage generated by a four pole generator with a 200 cm long coil spinning at a velocity of 20 $m.s^{-1}$ through a magnetic field with a strength of 12×10^{-3} tesla. (2)

[26]

QUESTION 5: (ELECTRICAL) SINGLE-PHASE TRANSFORMERS

5.1 The primary coil of a transformer has 200 turns and its secondary has 75 turns. The primary voltage is 160 volt and the primary current is 0,3 ampère.

Calculate:

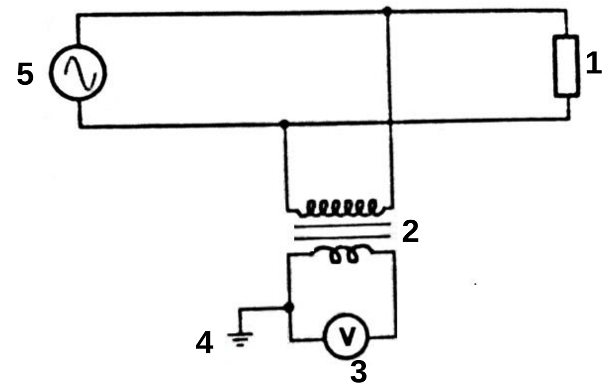
5.1.1 The transformer's secondary voltage (3)

5.1.2 The transformer's secondary current (3)

5.2 Show with the aid of a diagram the concept of 'mutual induction'. (4)

5.3 Draw a clear component diagram to represent an air-core transformer. (2)

5.4



5.4.1 Identify the above circuit diagram. (1)

5.4.2 Label numbers from 1–5. (5)

5.5 A circular coil with a radius of 8 mm has a magnetic field strength of 4 000 A/m. Calculate the following:

5.5.1 The coil magneto-motive-force (MMF) (3)

5.5.2 The current that must flow to create this MMF if the coil is wound with 600 turns (3)

5.6 Describe what effect leads to the formation of back-emf in a coil. (2)

[26]

QUESTION 6: (ELECTRICAL, ELECTRONICS AND DIGITAL) RLC-CIRCUITS

6.1 A coil has an inductance of 0,5 H and is connected to a 50 Hz supply. Calculate the reactance of the coil. (3)

6.2 Determine the capacitance of a capacitor if the capacitive reactance is 3 180 Ω when it is connected to a 300 Hz supply. (3)

6.3 Given a series circuit with a 600 Ω resistor, an inductive reactance of 37,7 Ω and a capacitive reactance of 665 Ω.

6.3.1 Determine the circuit impedance. (3)

6.3.2 Describe what occurs to the impedance of a series circuit when it reaches the point of resonance. (4)

6.3.3 Draw an impedance phasor diagram to support your description in QUESTION 6.3.2. (5)

6.4 Describe what effect an increase in frequency has on an inductive circuit. (2)

6.5 Calculate the resonant frequency of a series coupled RLC circuit where a resistance is 10 Ω, an inductance is 5 mH and a capacitance is 50 pF. (3)

6.6 Define the term: *frequency*. (1)

[24]

QUESTION 7: (ELECTRICAL) CONTROL DEVICES

7.1 Draw the complete DOL wiring diagram showing a motor protected by a thermal overload relay. (8)

7.2 Give TWO advantages that a DOL starter offers to its users. (2)

7.3 Determine the commonly used name for a Positive Temperature Coefficient device. (1)

7.4 Briefly descried the conditions under which the device mentioned in QUESTION 7.3 operates. (2)

7.5 State THREE causes of over-current situations. (3)

7.6 Which components of a circuit breaker determine the circuit breaker's capacity? (3)

7.7 Explain the harmful effect of an under voltage situation on an electric motor. (3)

7.8 Describe TWO instances where motors require monitoring against under-current situations occurring. (2)

7.9 Explain the benefits of an electronic overload relay over a normal circuit breaker. (3)

7.10 Give THREE classifications of overload relays. (3)

7.11 Name TWO excess current conditions that a fuse is designed to respond to. (2)

[32]

QUESTION 8: (ELECTRICAL) SINGLE-PHASE MOTORS

8.1 Draw the wiring diagram of a capacitor-start, capacitor run motor clearly labelling all parts. (10)

8.2 State the role a centrifugal switch plays in a capacitor start motor. (2)

8.3 Give FOUR advantages of an induction motor. (4)

8.4 Briefly explain what a synchronous motor is. (2)

8.5 How is the direction of rotation of a slip-phase motor reversed? (2)

8.6 Explain what is added to a single-phase motor to change it into a slip-phase. (2)

8.7 Explain how a universal motor is able to operate on an AC voltage supply. (2)

8.8 Give TWO advantages of a capacitor-start, capacitor run motor system. (2)

8.9 List TWO common electric motor driven devices which use a universal motor. (2)

8.10 What physical change is made to the stator coil to create the split-phase in these motors? (2)

[30]

**QUESTION 9: (ELECTRICAL)
POWER SUPPLIES**

9.1 Draw the circuit diagram of a full wave bridge rectifier. (5)

9.2 Describe the operation of a LC filter circuit. (2)

9.3 State clearly the purpose of a DC power supply. (2)

9.4 Explain how the capacitor smoothing circuit is able to smooth out the voltage ripple. (2)

9.5 Draw the block diagram of a shunt regulator connected in a circuit. (3)

9.6 Give the name of any filter circuit in use. (1)

9.7 Given a half wave rectifier circuit using a step down transformer that produces 57,5 V at its secondary. The load resistance is 240 Ω and the silicon diode used has a junction voltage of 0,65 V.

Calculate the following:

9.7.1 The peak secondary voltage (3)

9.7.2 The peak load voltage (3)

9.7.3 The average load voltage (3)
[24]

**QUESTION 10: (ELECTRONIC AND DIGITAL)
WAVE FORMS**

10.1 For a digital pulse waveform, explain the following terms:

10.1.1 Pulse width (3)

10.1.2 Fall time (3)

10.2 An AC voltage alternates 300 times in one minute:

10.2.1 Determine the frequency. (2)

10.2.2 What will the period be after 60 seconds? (3)

10.3 Describe the concept of *clamping* in electronics. (4)

10.4 Sketch TWO cycles of the following waveforms, clearly showing how they change above and below the zero line.

10.4.1 Sine wave (2)

10.4.2 Ramp wave (2)

10.4.3 Saw tooth wave (2)

10.5 Mention THREE applications of a radio wave. (3)

10.6 Draw the circuit diagram of a parallel clipping circuit. (2)
[26]

QUESTION 11: (ELECTRONICS AND DIGITAL) SEMICONDUCTOR DEVICES

11.1 Describe what happens at the PN junction when the diode is:

11.1.1 Forward biased (3)

11.1.2 Reverse biased (3)

11.2 Draw and label the circuit symbol of the following:

11.2.1 TRIAC (3)

11.2.2 DIAC (3)

11.3 Explain the application of a DIAC. (3)

11.4 Sketch an NPN transistor output characteristic curve, clearly labelling all lines and points. (10)

11.5 Describe the main characteristics of a Zener diode. (4)

11.6 Give ONE application of a Zener diode. (1)

11.7 State ONE advantage of a TRIAC. (1)

11.8 Determine TWO disadvantages of an SCR. (2)

11.9 Describe the term *solid state* with reference to semiconductors. (2)

11.10 Describe the term *holding current* with reference to a SCR. (2)

11.11 Explain ONE method to switch on a TRIAC. (2)

11.12 Below is the characteristic curve of a TRIAC.

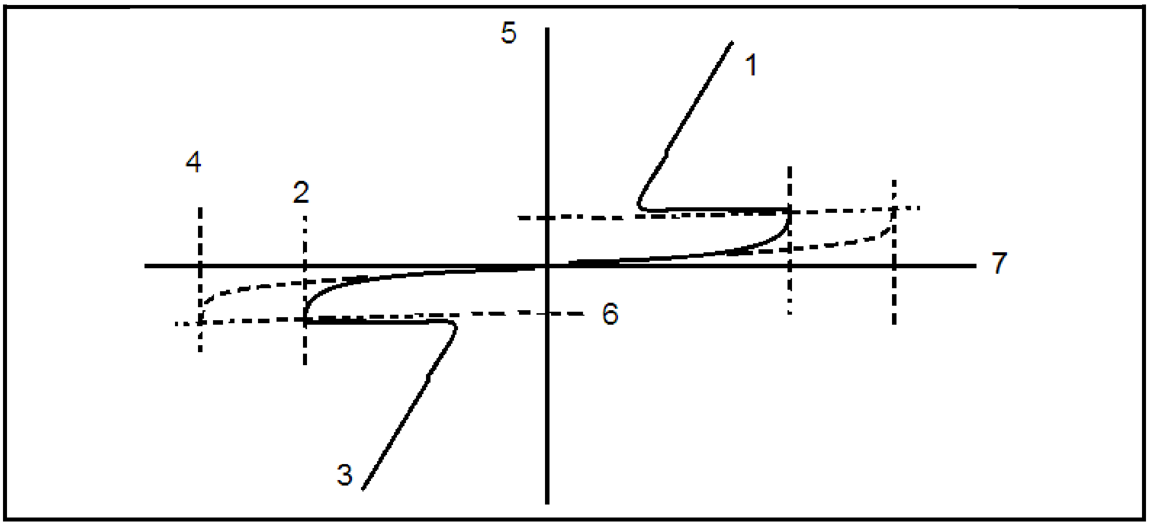


FIGURE 11.12

Label numbers **1** to **7**. (7)

11.13 Write the abbreviation SCR in full. (1)

11.14 Name ONE impurity which is added to pure silicon to create N-type material. (1)

[48]

QUESTION 12: (ELECTRONICS) POWER SUPPLIES

12.1 Draw the circuit diagram of a full wave bridge rectifier. (4)

12.2 Describe the operation of a LC filter circuit. (2)

12.3 State clearly the purpose of a DC power supply. (2)

12.4 Draw the block diagram of a shunt regulator connected in a circuit. (3)

12.5 Given a half wave rectifier circuit using a step down transformer that produces 57,5 V at its secondary and the load resistance is 240 Ω and the silicon diode used has a junction voltage of 0,65 V.

Calculate the following:

12.5.1 The peak secondary voltage (3)

12.5.2 The peak load voltage (3)

12.5.3 The average load voltage (3)

[20]

QUESTION 13: (ELECTRONICS) AMPLIFIERS

13.1 State THREE common types of transistor biasing connections. (3)

13.2 Draw the output characteristic curve of an NPN transistor and label it clearly. (5)

13.3 Give the disadvantage of a fixed base biasing when used on a common emitter transistor configuration. (2)

13.4 List THREE advantages of using negative feedback.in an amplifier. (3)

13.5 Explain the concept of *biasing* in amplifier circuits. (6)

13.6 Define an *amplifier*. (2)

13.7 The circuit below is constructed with a variable base biasing resistor, the transistor with a voltage of 0,6 V and a collector resistor of 1 kΩ.

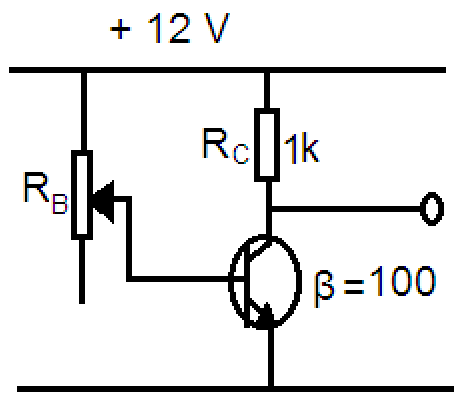


FIGURE 13.7

13.7.1 Determine the Q-point (Voltage and Current) when the resistance is set to the R_B = 285 kΩ. (2)

13.7.2 Calculate the collector current. (3)

13.8 Explain the purpose of a variable resistor. (3)

13.9 Draw the load line showing the maximum voltage and current that will flow through the amplifier in **FIGURE 13.7**. (3)

[32]

QUESTION 14: (ELECTRONICS AND DIGITAL) SENSORS AND TRANSDUCERS

14.1 Describe the basic principle of operation of a semiconductor gas sensor. (3)

14.2 Draw a labelled circuit diagram for an opto-coupler. (4)

14.3 Define the term: *transducer*. (1)

14.4 Name the electrical effect that quartz crystal exhibits when it is put under pressure. (1)

14.5 Explain how a load cell operates when relying on a four strain sensor. (3)

[12]

QUESTION 15: (ELECTRONICS AND DIGITAL) COMMUNICATION SYSTEMS

15.1 Define the term: *resonance.* (2)

15.2 State TWO components that form the heart of all resonant circuits. (2)

15.3 Explain what a phase locked loop circuit does. (2)

15.4 Describe the principle of a regenerative receiver circuit. (5)

15.5 Draw a clearly labelled block diagram of an AM radio receiver. (6)

15.6 Explain the application of Frequency Shift Keying. (2)

15.7 Below is the block diagram of an FM transmitter:

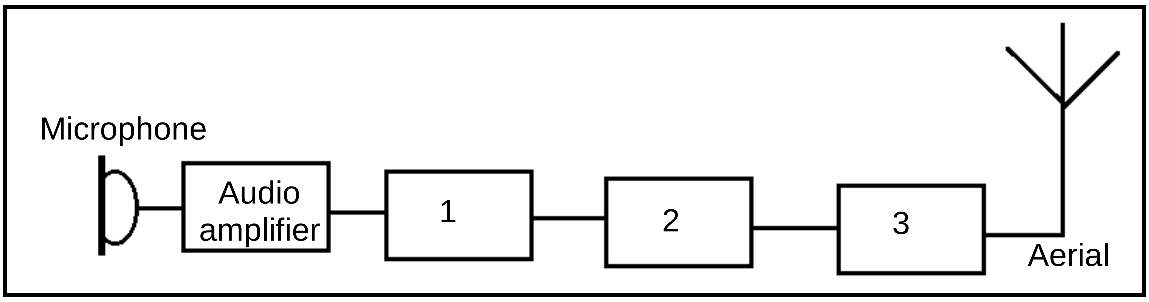


FIGURE 15.7

Label numbers from 1–3. (3)

15.8 Give and describe TWO advantages gained from the use of the SSB system. (4)

[26]

QUESTION 16: (DIGITAL) LOGIC

16.1 Refer to **FIGURE 16.1** below and answer the questions that follow.

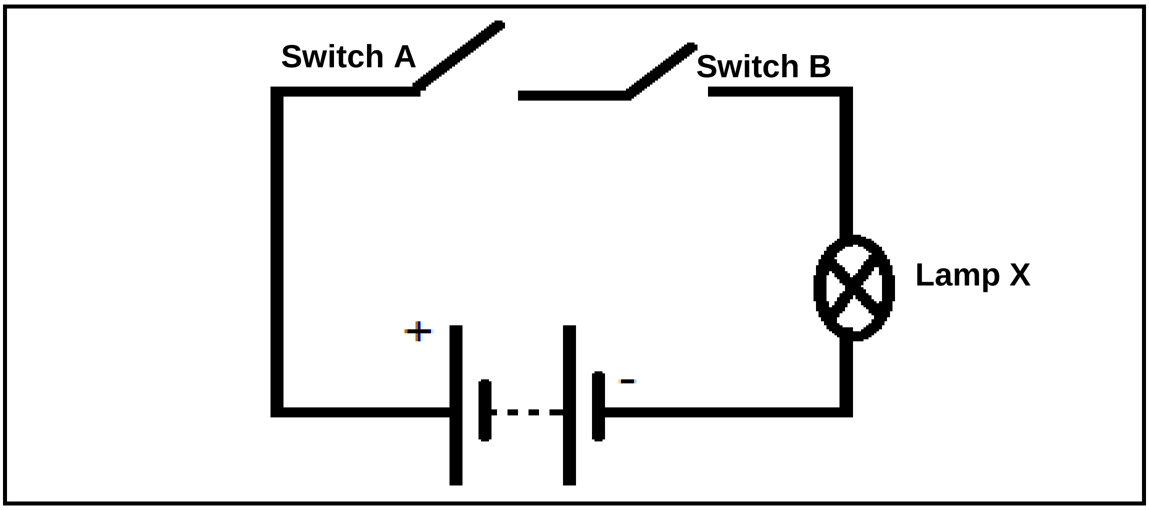


FIGURE 16.1

16.1.1 Identify the logic function of the circuit in **FIGURE 16.1**. (1)

16.1.2 Draw the truth table of the gate. (4)

16.1.3 Write out the Boolean expression. (2)

16.1.4 Draw the logic symbol that is represented by the circuit. (2)

16.2 Refer to **FIGURE 16.2** below and answer the questions that follow.

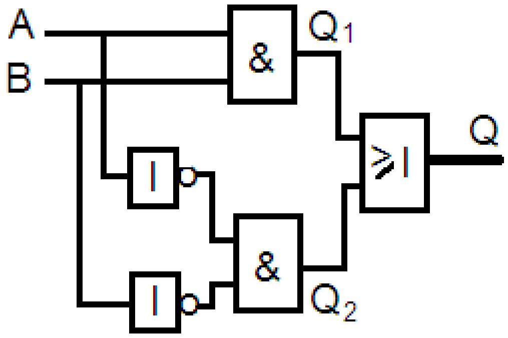


FIGURE 16.2

Write the Boolean expression at the following points:

16.2.1 Q_1 (2)

16.2.2 Q_2 (2)

16.2.3 Q (3)

16.3 Use the Boolean expression below to answer the questions that follow:

$$Q = A\bar{B}\bar{C} + \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + AB\bar{C}$$

16.3.1 Simplify the Boolean expression using a *Karnaugh* map. (8)

16.3.2 Give the simplified equation. (2)

16.3.3 Draw the logic diagram of the final minimised expression. (4)

16.4 Design a half adder. In your design, include:

16.4.1 The truth table (2)

16.4.2 Simplified expressions (2)

16.4.3 Draw the logic diagram (4)

16.5 State TWO advantages of a Logic probe tester. (2)

[40]

QUESTION 17: (DIGITAL)
POWER SUPPLIES

17.1 Draw the circuit diagram of a full wave bridge rectifier. (4)

17.2 Describe the operation of a LC filter circuit. (2)

17.3 State clearly the purpose of a DC power supply. (2)

17.4 Draw the block diagram of a shunt regulator connected in a circuit. (3)

17.5 Give the name of any filter circuit in use. (1)
[12]

TOTAL: 200

ELECTRICAL TECHNOLOGY: GRADE 11

FORMULA SHEET

SINGLE-PHASE AC GENERATION

Magnetic field strength

$H = \frac{N \times I}{l} (A/m)$

Flux density = $\beta = \frac{\varphi}{A}$ $(tesla)$

Pole pairs

p = $\frac{number\ of\ poles}{2}$

Area of the coil

$A = l \times b$(m^2)

Frequency of rotation

f = $\frac{1}{T}$ $(hertz)$

f = p x n (hertz)

Instantaneous value

$\omega = 2\pi f\ (radians)$
$\theta = \omega t\ (degrees)$
$i = I_{MAX} \times \sin\theta$ (A)
$v = V_{MAX} \times \sin\theta\ (V)$

Maximum value

$V_{max} = V_{RMS}$ x 1,414 (V)
$V_{max} = 2\pi\ \beta A n N\ (V)$
E = Blv (V)

RMS value

$V_{RMS} = V_{max}$ x 0,707 (V)

Average value
$V_{ave} = V_{max}$ x 0,637 (V)

SINGLE-PHASE TRANSFORMER

Power

$P = VI\cos\theta\ \ (Watt)$

$S = VI$ (VA)
$P = VI\sin\theta\ (kVA_r)$

Ratio Calculation

$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p}$

η = $\frac{P_{OUT}}{P_{IN}} \times 100\%$

RLC CIRCUITS

Inductive reactance

$X_L = 2\pi f L\ (\Omega)$

Capacitive reactance

$X_C = \frac{1}{2\pi f C}\ (\Omega)$

Impedance

Z = $\sqrt{R^2 + (X_L - X_c)^2} (\Omega)$

Power
$P = VI\cos\theta\ \ (watt)$

Power factor

Cos $\theta = \frac{R}{Z}$

Cos $\theta = \frac{V_R}{V_Z}$

Phase angle $\theta = \text{Cos}^{-1} \frac{R}{Z}$ (degrees) $\theta = \text{Cos}^{-1} \frac{V_R}{V_Z}$ (degrees) Resonance frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$ (hertz) Q-factor $q = \frac{1}{R}\sqrt{\frac{L}{C}}$ $q = \frac{X_C}{R}$	**POWER SUPPLY** $P = V_Z \times I_Z$ (watt) $R_S = \frac{V_S - V_Z}{I_Z}$ (watt) $I_L = \frac{V_Z}{R_L}$ (ampère)
	AMPLIFIERS $I_C = \frac{V_{CC}}{R_C + R_E}$ (ampère)
CONTROL DEVICES $I_{op} = I_{max} \times 125\%$ (ampère)	Bandwidth $BW = \frac{f_r}{q}$ (hertz)