WORKFORCE DEVELOPMENT AUTHORITY

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# ADVANCED LEVEL NATIONAL EXAMINATIONS, 2015,

# TECHNICAL AND PROFESSIONAL TRADES

**EXAM TITLE:** **General Electronics**

**OPTIONS:** - **Computer Electronics (CEL)**

- **Electronics and Telecommunication (ETL)**

**DURATION:** **3hours**

## INSTRUCTIONS:

The paper is composed of **three (3) Sections**:

Section **I**: Fifteen **(15)** questions, all **Compulsory**. **55marks**

Section **II**: Five **(5)** questions, **Choose Three (3) only.** **30marks**

Section **III**: Three **(3)** questions, **Choose only One (1).** **15marks**

**Every candidate is required to strictly obey the above instructions. Punishment measures will be applied to anyone who ignores these instructions.**

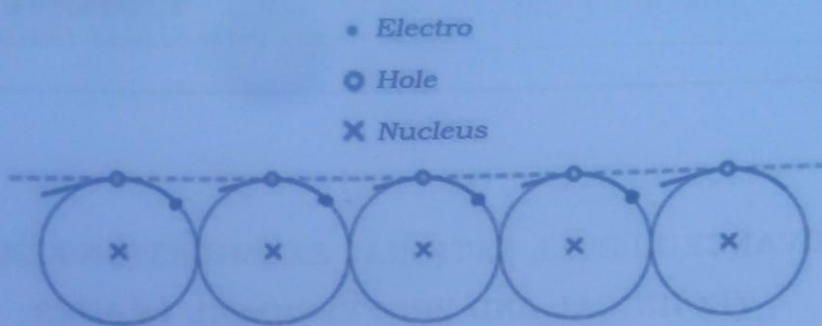
**Section I. Fifteen (15) Compulsory questions. 55marks**

01. What is electricity? **2marks**

02. What is the difference between conductors and insulators? **2marks**

03. Define doping process? **2marks**

04. Show the direction of electron and hole from the figure below. **2marks**




05. Give the value of resistor for the figure below, using color code.

*Brown, black, red, silver*

**2marks**

06. Refer to the given formula, give the four factors affecting resistor. **4marks**

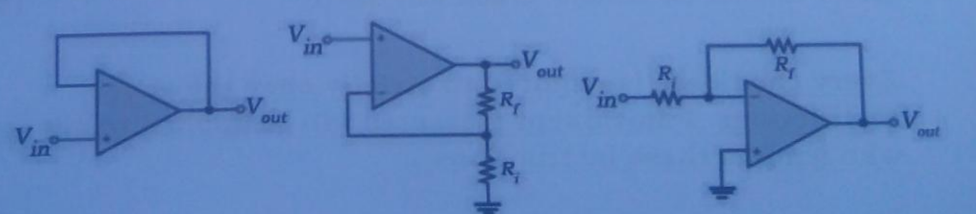
$$R = \rho \frac{\ell}{A} \text{ ohm}$$

07. From the given binary number 01101011show the MSB and the LSB. **4marks**

08. Convert the decimal number 1993 into octal number. **5marks**

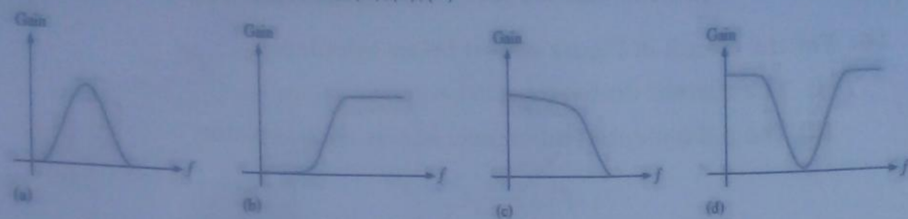
09. Convert binary number$1011.101_2$ to decimal number. **4marks**

10. Identify each of the op-amp configurations in figure (a), (b), (c). **3marks**

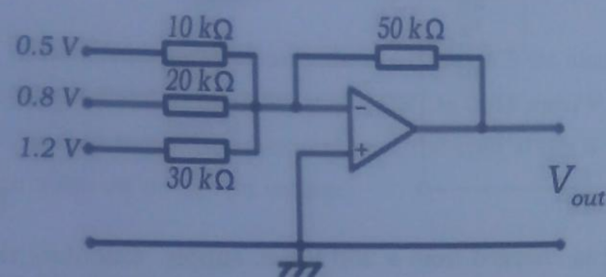



(a) (b) (c)

Identify each type of filter response (low-pass, high-pass, band-pass, or band-stop filter) in figure (a),(b),(c),(d) **6marks**

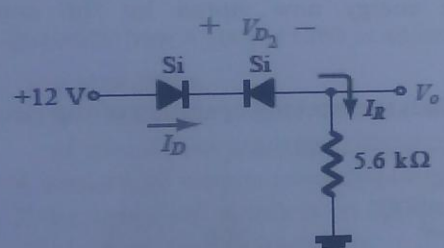



**12.** For the summing op amp shown in figure below, determine the output voltage, $V_o$



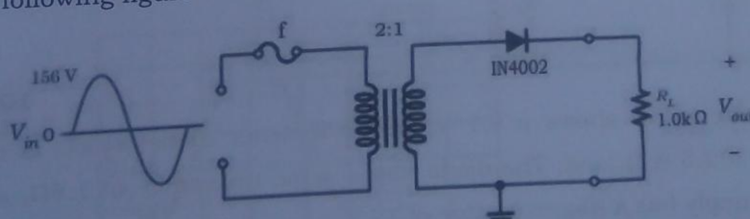

**4marks**

**13.** Determine $I_D$, $V_{D2}$, and $V_o$ for the circuit of figure below.




**6marks**

**14.** Determine the peak value of the output voltage for the circuit of the following figure




**6marks**

**15.** Light Emitting Diodes are made from compound type semiconductor materials such as........................ **3marks**

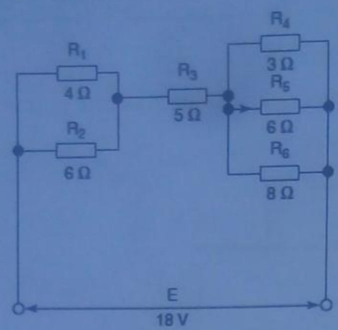
**Section II. Answer any three (3) questions of your choice**

**(Do not choose more than three questions). 30marks**

**16.** For the circuit of Figure shown below calculate:

**(i)** The current drawn from the source,

**(ii)** The p.d.(potential difference) across each resistor.

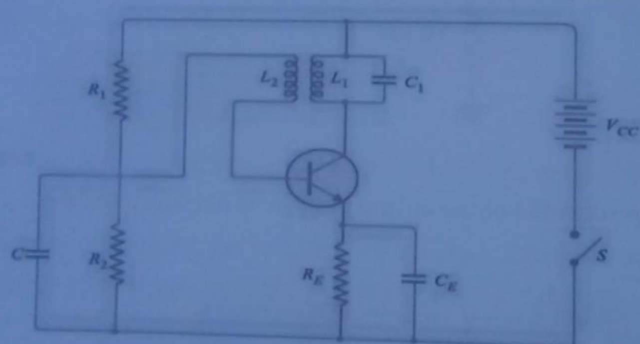



**10marks**

**17.** A 3 µ F capacitor is charged from a 250 V d.c. supply. Calculate the charge and energy stored. The charged capacitor is now removed from the supply and connected across an uncharged 6 ΩF capacitor. Calculate the p.d. between the plates and the energy now stored by the combination.

**10marks**

**18.** Give the name and briefly explain the working operation of the circuit below.



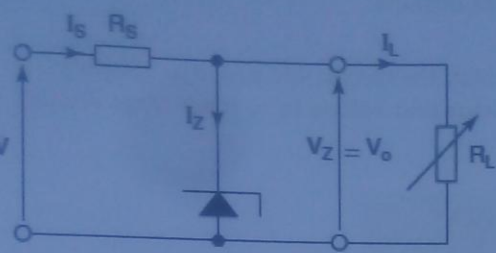

**10marks**

**19.** The figure below shows a 9.1 V, 500 mW zener diode which is used to supply a 2.5 k Ω load. The diode has a slope resistance of 1.5Ω, and the input supply has a nominal value of 12 V.

(a) Calculate a suitable value for the series resistor Rs.

(b) Calculate the value of diode current when the load resistor is connected to the circuit.

(c) If the input supply voltage decreases by 10%, calculate the percentage change in the p.d. across the load.




**10marks**

**20.** a. Show Main parts of cathode ray tube on neat sketch.

b. The deflection sensitivity of a CRT is 0.03 mm/V. If an unknown voltage is applied to the horizontal plates, the spot shifts 3 mm horizontally. Find the value of unknown voltage. **10marks**

**Section III. Answer any one (1) question of your choice**

**(Do not choose more than <u>one question</u>).** **15marks**

**21.** a) Describe how a simple CRO is adjusted to give

i) a spot trace,

ii) a continuous horizontal trace on the screen, explaining the functions of the various controls.

b) A sinusoidal voltage trace displayed by a CRO is shown in Figure below. If the 'time/cm' switch is on 500 μs/cm and the 'volts/cm' switch is on 5 V/cm, find, for the waveform,

i) the frequency,

ii) the peak-to- peak voltage,

iii) the amplitude,

iv) the r.m.s. value.

**15 marks**

**22.** A filter section is to have a characteristic impedance at zero frequency of 600Ω and a cut-off frequency at 5 MHz Design:

(a) a low-pass T section filter, and

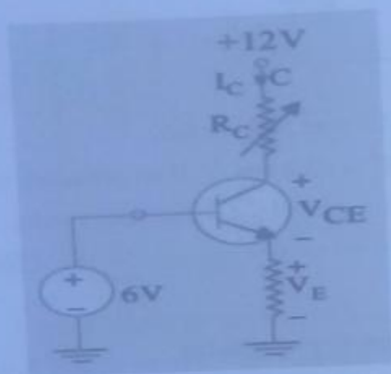
(b) a low-pass Λ section filter to meet these requirements. **15 marks**

23. The circuit of Fig. below is designed to produce nearly constant current through the variable collector load resistance. An ideal 6V source is used to establish the current. Determine:

(a) Value of $I_C$ and $V_E$,

(b) Range of $R_C$ over which the circuit will function properly.

Assume silicon transistor and values in a, b are large enough to justify the assumptions used.




**15 marks**

SEC. I.

01. Electricity can be defined as:

(i) a form of energy resulting from the existance of charged particles (such electrons or protons) either statically as an accumulation of charges or dynamically as a current.

(ii) a state or feeling of thrilling excitements.

(iii) a set of physical phonena associated with the presence and flow of electric charge.

(iv) the part of physics which deal with study of static charge and electrons in motion.

(v) the [illegible] motion of electrons

Do not write in this margin

/2

02. Difference between conductors and insulators:

| Conductors | Insulator |
| --- | --- |
| i. Low resistivity | i. High resistivity |
| ii. Large number of free electrons | ii. No free electrons |
| iii. Positive temperature coefficient of resistance | iii. Negative temperature coefficient of resistance |
| iv. Conduction and valence bands are overlapped | iv. Conduction and valence bands are separated by a large energy gap. |
| v. Conduction band is full of free electrons | v. Conduction band is empty |
| vi. Allow electrical current to pass through them | vi. do not allow electrical current to pass through them. |

Any one on each side

Or

Conductor is a material having a low resistance that allow electric current to pass through it, whereas an insulator is a material differing a high resistance that does not allow electric current to pass through it.

Or

Materials with high electron mobility (many free electrons) are called conductors, while materials with low electron mobility (few or no free electrons) are called insulators

/2

03. Doping process: is a process of adding an impurity atom to a pure semiconductor in a controlled manner.

/2

04. ⟵ Electrons

⟶ Holes

/2

05. Brown Black Red Silver
1 0 $10^2$ $\pm 10\%$

$R = (10 \times 10^2)\,\Omega \pm 10\%$
$= 1000\,\Omega \pm 10\%$ ✓ ✓
or
$1k\Omega \pm 10\%$ ✓ ✓

Do not write in this margin

/2

06. Factors affecting resistor refer to $R = \frac{\rho l}{A}$ ohm :

(i) Length of material ✓
(ii) Cross sectional area ✓
(iii) Nature of the material (resistivity) ✓
(iv) Temperature ✓

/4

07. 0 1101011
MSB (2) LSB (2)

/4

08. $1993_{10} = ?_{(8)}$

| | |
|---|---|
| 8 | 1993 |
| 8 | 249 − 1 ✓ |
| 8 | 31 − 1 ✓ |
| 8 | 3 − 7 ✓ |
| | 0 − 3 ✓ |

$\therefore 1993_{10} = 3711_8$ ✓

or

1993 ÷ 8 = 249 remainder ① ✓; 249 ÷ 8 = 31 remainder ① ✓; 31 ÷ 8 = 3 remainder ⑦ ✓; 3 ÷ 8 = 0 remainder ③ ✓

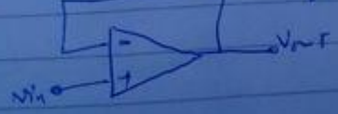
$\therefore 1993_{10} = 3711_8$ ✓

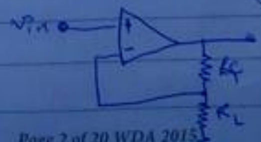
/5

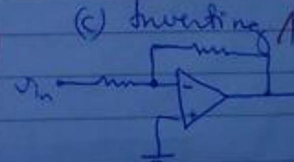
09. $1011.101_2 = ?_{(10)}$
$= (1\times2^3)+(0\times2^2)+(1\times2^1)+(1\times2^0)+(1\times2^{-1})+(0\times2^{-2})+(1\times2^{-3})$ ✓
$= (1\times8)+(0\times4)+(1\times2)+(1\times1)+(1\times\frac{1}{2})+(0\times\frac{1}{4})+(1\times\frac{1}{8})$ ✓
$= 8+0+2+1+0.5+0+0.125$ ✓
$= 11.625_{10}$ ✓
$\therefore 1011.101_2 = 11.625_{10}$

/4

10. (a) Voltage follower ✓ (buffer) / emitter follower (b) Non-inverting ✓ (c) Inverting ✓





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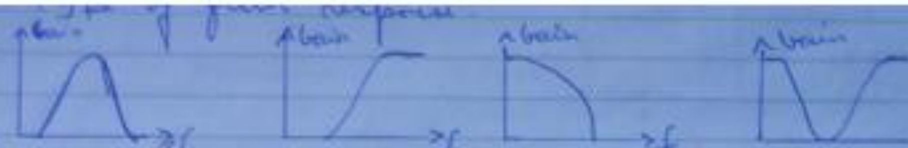
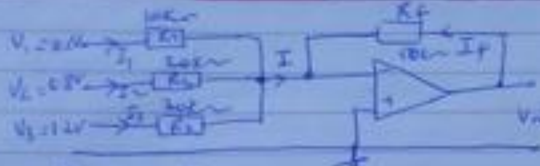


a) Band pass 1   b) High pass 1   c) Low pass 1   d) Band stop 1   /6

12.



$I = -I_f$

$I_1 + I_2 + I_3 = -I_F \iff \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} = -\frac{V_{out}}{R_f}$

$\iff V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$ 1   /4

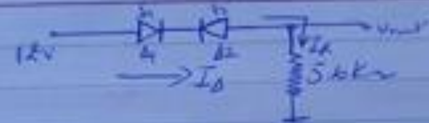
$= -(50\times10^3)\left(\frac{0.5}{10\times10^3} + \frac{0.8}{20\times10^3} + \frac{1.2}{30\times10^3}\right)$ 1

$= (-50\times10^3)(5\times10^{-5} + 4\times10^{-5} + 4\times10^{-5})$

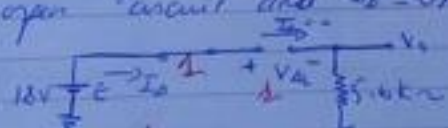
$= (-50\times10^3)\cdot(13\times10^{-5})$

$= -5\times13\times10^4\times10^{-5} = -6.5V$ 1 1

13.



The combination of a short in series with an open circuit always results in an open circuit and $I_D = 0A$, $V_{A_1} = 0V$



$V_o = I_R R = I_D R = (0A)R = 0V$ 1

$V_{D_2} = V_{open\ circuit} = E = 12V$ 1   /6

or applying kirchhoff's voltage law in clockwise direction gives us

$E - V_{D_1} - V_{D_2} - V_o = 0$

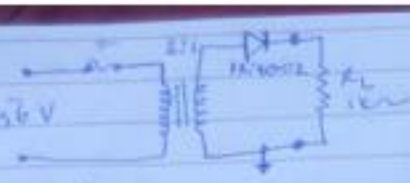
and $V_{D_2} = E - V_{D_1} - V_o = 12V - 0 - 0$

$= 12V$ 1

with $V_0 = 0$

14.

$V_{max}$ 156 V




Formula:

$\frac{V_{PMax}}{V_{SMax}} = \frac{N_P}{N_S}$ 1 $\Rightarrow V_{SMax} = \frac{N_S}{N_P} \cdot V_{PMax} = 156 \times \frac{1}{2} = 78V$ 1

$V_{OMax} = V_{SMax} - V_D$ 1

For ideal diode $V_D = 0V$ 1

$V_{OMax} = V_{SMax} = 78V$ 1

or

1N4002 is made from silicon (Si), $V_D = 0.7V$ 1

$V_{OMax} = V_{SMax} - V_D = 78 - 0.7 = 77.3\ V$ 1

15. Light emitting diode are made from compound type semiconductor materials such as:

(i) Gallium Arsenide (GaAs) 1

(ii) Gallium Phosphide (GaP) 1

(iii) Gallium Arsenide Phosphide (GaAsP) 1

(iv) Indium phosphide (InP) 1

(v) Silicon carbide (SiC) 1

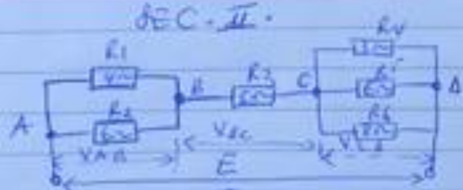
(vi) Gallium Indium Nitride (GaInN) 1

/3

Any three only

SEC. II.

16.




$E = V_{AB} + V_{BC} + V_{CD}$ (18V)

$R_{AB} = R_1 \| R_2 = \frac{R_1 R_2}{R_1 + R_2} = \frac{4 \times 6}{4+6} = \frac{24}{10} = 2.4\Omega$

$R_{CD} = R_4 \| R_5 \| R_6 = \frac{R_4 \times R_5 \times R_6}{R_4R_5 + R_4R_6 + R_5R_6} = \frac{3 \times 6 \times 8}{18 + 24 + 48} = \frac{144}{90} = 1.6\Omega$

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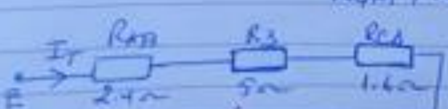


$R_T = R_{AB} + R_3 + R_{CD}$

$= 2.4 + 5 + 1.6 = 9\Omega$

$I_T = \frac{E}{R_T} = \frac{18}{9} = 2A$

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- $V_{R_{AB}} = V_{R_1} = V_{R_2} = I_T R_{AB} = 2 \times 2.4 = 4.8V$ 1
- $V_{R_3} = I_T \cdot R_3 = 2 \times 5 = 10V$ 1
- $V_{CD} = V_{R_4} = V_{R_5} = V_{R_6} = I_T \cdot R_{CD} = 2 \times 1.6 = 3.2V$ 1

1 1

17. $C_1 = 3\mu F$

$V_1 = 250V$

$C_2 = 6\mu F$

$Q_1 = C_1 V_1 = 3 \times 10^{-6} \times 250 = 750\mu C$ 1 1

$W_1 = \frac{1}{2} C_1 V_1^2 = \frac{1}{2} 3 \times 10^{-6} \times (250)^2 = 93750 \times 10^{-6} J$ 1

$= 93.75 mJ$ 1

When the two capacitors are connected in parallel the 3μF will share its charge with 6μF capacitor. Thus, the total charge in the system will remain unchanged, but the total capacitance will now be different: 1

Total capacitance, $C_T = C_1 + C_2 = 3 + 6 = 9\mu F$ 1

$V_2 = \frac{Q}{C_T} = \frac{750 \times 10^{-6}}{9 \times 10^{-6}} = 83.33V$ 1 1

$\therefore W = \frac{1}{2} C_T V_2^2$ 1

$= \frac{1}{2} \times 9 \times 10^{-6} \times 83.33^2$

$= 31.25 mJ$ 1

⚠ The student who will say that, the unit of the capacitors is not well given, s(he) will get 3 marks.

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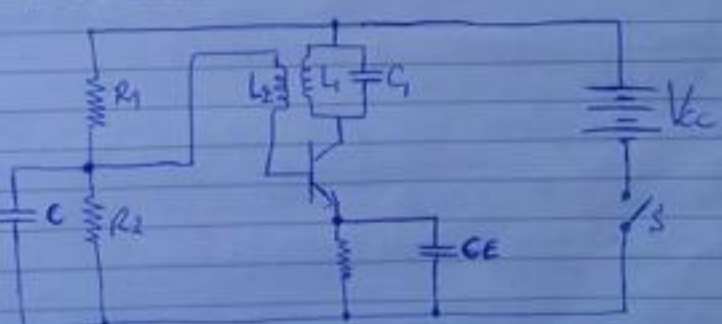
18. Given the circuit

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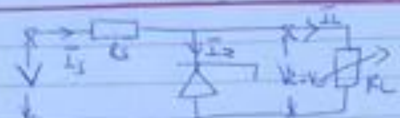
i) The name of the circuit is a tuned collector oscillator. 1/2

ii) Working operation of the circuit:

When the switch is closed, collector current starts increasing and charges the capacitor $C_1$. When this capacitor is fully charged, it discharges through coil $L_1$, setting up oscillations of frequency $f = \frac{1}{2\pi\sqrt{L_1 C_1}}$. These oscillations induce some voltage in coil $L_2$ by mutual induction. The frequency of voltage in coil $L_2$ is the same as that of tank circuit but its magnitude depends upon the number of turns of $L_2$ and coupling between $L_1$ and $L_2$. The voltage across $L_2$ is applied between base and emitter and appears in the amplified form in the collector circuit, thus overcoming the losses occurring in the tank circuit. The number of turns of $L_2$ and coupling between $L_1$ and $L_2$ are so adjusted that oscillations across $L_2$ are amplified to a level just sufficient to supply losses to the tank circuit and the balanced is radiated out in the form of electro-magnetic waves.

19.




Data: $V_z = 9.1V$, $P_{max} = 500mW$, $R_L = 2.5k\Omega$, $r_z = 1.5\Omega$, $V_i = 12V$

Unknowns:

a) $R_s$

b) $I_z$, when the load is connected

c) % change in the p.d across the load.

Resolution

a) $R_s = \frac{V - V_z}{I_s}$

With no load, $I_s = I_{z max}$

$P_{max} = V_z I_{z max} \Rightarrow I_{z max} = \frac{P_{max}}{V_z} = \frac{500 \times 10^{-3}}{9.1} = 54.94 mA \cong 55 mA$

$\therefore R_s = \frac{12 - 9.1}{55 \times 10^{-3}} = 52.7\Omega \cong 53\Omega$

b) $I_s = I_z + I_L$ (with load connected)

$I_L = \frac{V_L}{R_L} = \frac{V_z}{R_L} = \frac{9.1}{2.5 \times 10^{3}} = 3.64 mA$

$I_z = I_s - I_L = 55 - 3.64 = 51.36 mA$

c) $V_{new} = V - \frac{10}{100} V = 12 - \frac{10}{100} \cdot 12 = 10.8V$

Thus, $I_{s_{new}} = \frac{V - V_z}{R_s} = \frac{10.8 - 9.1}{53} = 0.032A = 32mA$

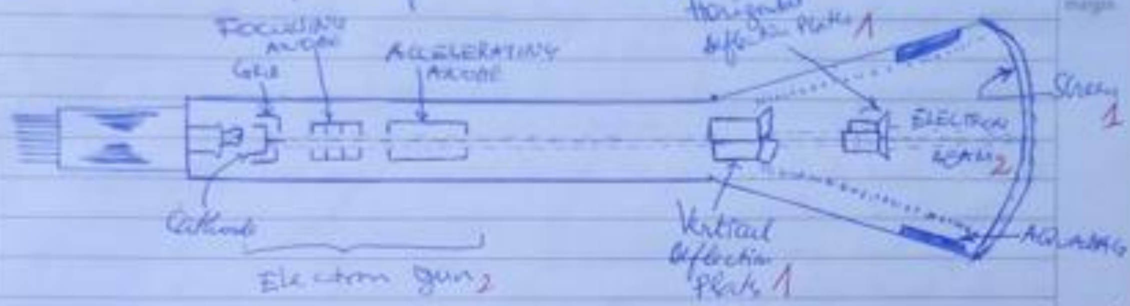
$I_{z_{new}} = I_s - I_L = 32 - 3.64 = 28.36 mA$

$\Delta I_z = I_z - I_{z new} = 51.36 - 28.36 = 23 mA$

Therefore $\Delta V_z = \Delta I_z \times r_z = 23 \times 1.5 = 34.5mV = 0.0345V$

Thus the voltage applied to the load change by 0.0345V which expected % is $\frac{0.0341}{9.1} \times 100 = 0.379\%$ (compared with a 10% change in supply)

20. a) Main parts of cathode ray tube are mentioned.




b) the value of unknown voltage
Deflection sensitivity = 0.03mm/V
Spot shift = 3mm
Now, spot shift = deflection sensitivity x applied voltage
applied voltage = $\frac{\text{spot shift}}{\text{deflection sensitivity}}$ 1

$= \frac{3mm}{0.03mm/V}$ 1 $= 100V$ 1

SEC III

21. i. To obtain a spot on a simple CRO screen
a. Switch on the CRO after connecting it to the supply. 1
b. Switch the time base control to OFF. This control is calibrated in time per centimetres. for ex 5ms/cm or 100 µs/cm. Turning it to zero ensures no signal applied to the X-plate. The Y-plate input is left open-circuited. 1
c. Set the intensity, X-shift and Y-shift controls to about the mid-range position. 1
d. A spot trace should now be observed on the screen. If not adjust either or both of the X and Y-shift control. The X-shift control varies the position of the spot trace in a horizontal direction while the Y-shift control varies its vertical position. 1
e. Use the X and Y-shift controls to bring the spot to the centre of the screen and use the focus control to focus the electron beam into a small circular spot. 1

ii. To obtain a continuous horizontal trace on the screen the same procedure as in (i) is initially adopted. Then the timebase control is switched to a suitable position, initially the millisecond timebase range, to ensure that the repetition rate of the crowtook is sufficient for the persistence of the vision time of the screen phosphor to hold a given trace.

2. a) The width of the complete cycle is 4cm. Hence the periodic time, T is 4cm × 500 μs/cm, ie 2ms

Frequency, $f = \frac{1}{T} = \frac{1}{2\times10^{-3}} = 500\,Hz$

b) The peak to peak height of the waveform is 5cm. Hence the peak to peak voltage $= 5cm \times 5V/cm = 25V$

c) Amplitude $= \frac{1}{2} \times 25V = 12.5V$

d) The peak value of voltage is the amplitude, ie 12.5V

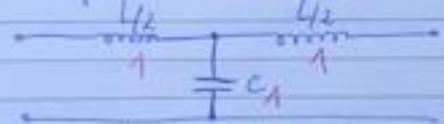
rms voltage $= \frac{\text{Peak voltage}}{\sqrt{2}} = \frac{12.5}{\sqrt{2}} = 8.84V$

22. Data

$f_c = 5MHz = 5\times10^6\,Hz$

$R_o = 600\,\Omega$

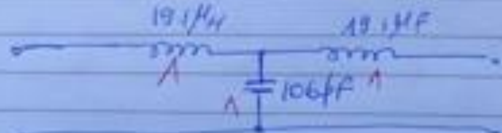
a) Low pass T section filter




$$C = \frac{1}{\pi R_o f_c} = \frac{1}{3.14\times600\times5\times10^6} = 106\,pF$$

$$L = \frac{R_o}{\pi f_c} = \frac{600}{3.14\times5\times10^6} = 38.2\,\mu H$$

$$\therefore \frac{L}{2} = \frac{38.2}{2} = 19.1\,\mu H$$




b) Low pass π section filter


$$\frac{C}{2} = \frac{106}{2} = 53\,pF$$

23. Data

$V_{CC} = 12V$

$V_{BB} = 6V$

$V_{BE} = 0.7V$

a) Considering the loop on the left side of the circuit, we get:

$V_{BB} - V_{BE} - V_E = 0$

$V_E = V_{BB} - V_{BE} = 6 - 0.7 = 5.3V$

$V_E = I_E R_E \iff I_E = \frac{V_E}{R_E} = \frac{5.3}{R_E}(A)$

Assume that $I_E \cong I_C$, $I_C \cong \frac{5.3}{R_E}(A)$

b) On the collector emitter side

$V_{CC} - I_C R_C - V_{CE} - I_E R_E = 0$

$V_{CC} - I_E R_E - V_{CE} - I_C R_C = 0$

$$R_C = \frac{V_{CC} - I_E R_E - V_{CE}}{I_C} = \frac{12 - 5.3 - V_{CE}}{I_C}$$

$$R_C = \frac{6.7 - V_{CE}}{I_C}$$

$$R_{C(min)} = \frac{6.7 - V_{CE}}{I_{C(sat)}} (\Omega)$$

$= \frac{6.7}{I_{C(sat)}} (\Omega)$, since $V_{CE} \cong 0V$ at saturation and $I_C$ is maximum

$$R_{C(max)} = \frac{6.7 - V_{CE}}{I_{C(min)}} \Omega$$

End!