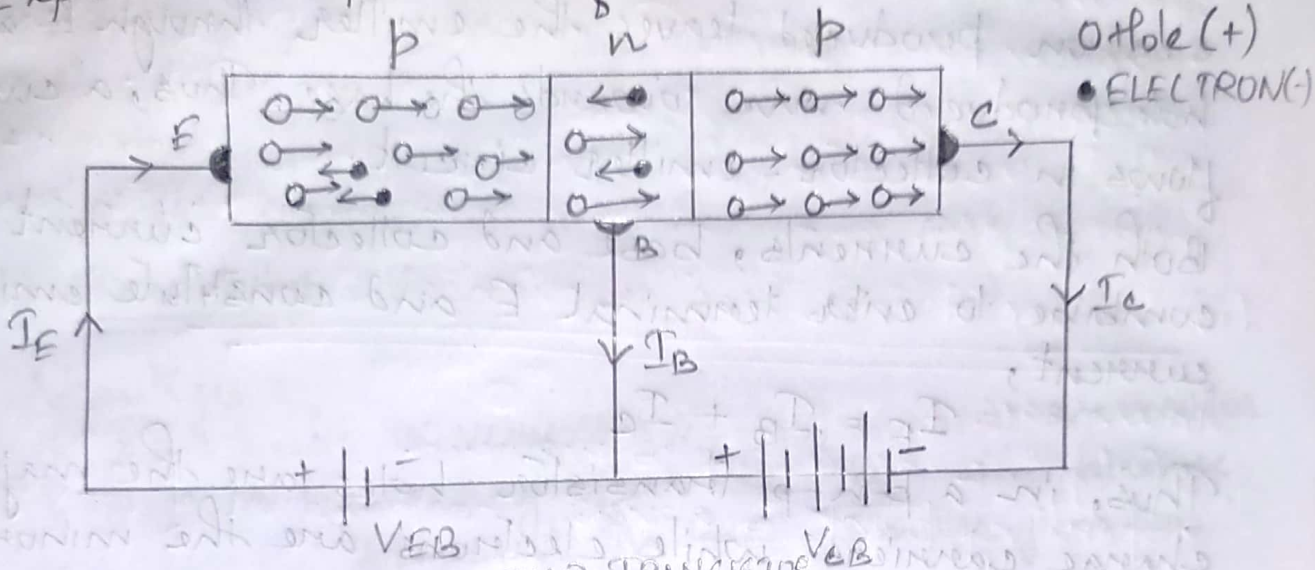
18CSS 201J - Analog and Digital Electronics
Assignment 1

Set - 1

1. Explain the operation of PNP Transistor



PNP TRANSISTOR

A common base circuit of a p-n-p transistor is shown above.

The emitter-base junction on the left is given a small forward bias by an emitter-base battery V_{EB}, while the base-collector junction is given a large bias by another battery V_{CB}.

Under forward bias the holes in the emitter move towards the base while negative electrons in the base move towards the emitter. Since the base is very thin most of the holes entering it pass onto the collector, while a very few of them combine with electrons present in the base. As soon as holes combine with an electron, a fresh electron leaves the negative pole of the battery V_{EB} and enters the base. At the same moment an electron leaves the emitter through terminal E and enters positive pole of the battery V_{EB}. This creates a hole in the emitter which starts moving towards the base. Thus, a small current flows in the base-emitter circuit.

The holes entering the collector move under it's reverse bias, and reach the terminal C. As soon as hole reaches C, an electron leaves negative pole of V_{CB} and neutralises hole. At the same moment a covalent bond is broken in the emitter and electron produced leaves the emitter through E and hole produced move towards the base. Thus, a current flows in collector - emitter circuit.

Both the currents, base and collector current combine to enter terminal E and constitute emitter current,

$$I_E = I_B + I_C$$

Thus, in a p-n-p transistor holes are the majority charge carriers while electrons are the minority charge carriers.

2. Calculate I_C and I_E for a transistor that has $\alpha_{dc} = 0.98$ and $I_B = 100\mu A$. Find β_{dc}.

Sol^n: We know, $\alpha = \dfrac{\beta}{\beta+1}$

$\Rightarrow 0.98 = \dfrac{\beta}{\beta+1}$ $\Rightarrow 0.98\beta + 0.98 = \beta$

$\Rightarrow 0.02\beta = 0.98$ $\Rightarrow \boxed{\beta_{dc} = 49}$

$\beta = \dfrac{I_C}{I_B}$ $\Rightarrow 49 = \dfrac{I_C}{100}$ $\Rightarrow \boxed{I_C = 4900\mu A \text{ or } 4.9mA}$

$\alpha = \dfrac{I_C}{I_E}$

$\Rightarrow 0.98 = \dfrac{4900}{I_E}$ $\Rightarrow I_E = \dfrac{4900}{0.98}$

$\Rightarrow \boxed{I_E = 5000\mu A \text{ or } 5mA}$

3. What is the various method used for transistor biasing? State their advantages and disadvantages.

Soln The various methods for transistor biasing are:

- Fixed bias
- Collector - to - base bias.
- Fixed bias with emitter resistor.
- Voltage divider bias or potential divider.
- Emitter bias.

(i) Fixed bias

Advantages:

- The circuit is very simple as it requires one resistor.
- There is no loading effect at input side because no resistor is present in Base - Emitter junction.

(ii) Disadvantages:

- The transistor is very β - sensitive and variation of beta can cause temperature increase in transistor and hence is very unstable to temperature stability.
- This method has strong chances of thermal runaway.

(ii) Collector-to-base bias

Advantages:

- Circuit stabilises the point operating against variations in temperature and β (replacement of transistor).
- Circuit stabilises the operating point against Vcc.

Disadvantages:

- The resistor causes an AC feedback, reducing voltage gain of the amplifier.
- Although small changes in β are OK, large changes in β greatly affects the operating point.

(iii) Fixed bias with emitter resistor.

Advantages :
- Only the circuit has tendency to stabilise operating point against changes in temperature and β- value.

Disadvantages :
- The emitter resistor Re causes negative feedback which reduces voltage gain of the amplifier.
- If Re value is high, high Vcc is necessary which increases cost as well as precautions necessary in handling

(iv) Voltage divider bias or potential divider.

Advantages :
- Only one dc supply is required.
- Operating point is almost independent of β- variation

Disadvantages :
- As well as one dc feedback is caused by Re, which reduces the A.C. voltage gain of the amplifier.
- If the value is large, high Vcc is necessary which increases cost as well as precautions.

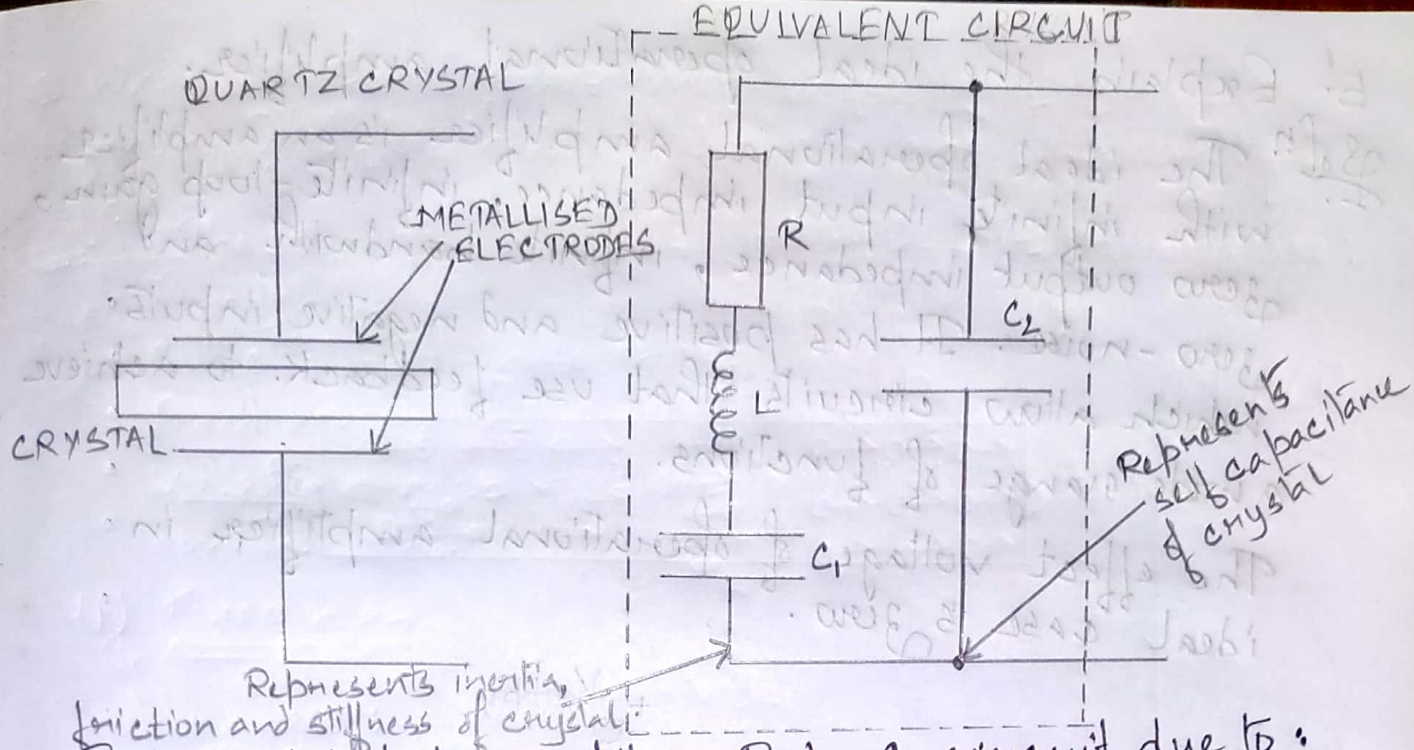
(v) Emitter bias.

Advantages :
- The operating point is independent of β.

Disadvantage :
- It can only be used when split power supply is available.

4. Explain the operation of crystal oscillator with neat diagram.

Solⁿ: Crystal oscillator operates on the principle of inverse piezoelectric effect in which an alternating voltage applied across the crystal surfaces causes it to vibrate at its natural frequency. It is these vibrations which get converted into oscillations. In crystal oscillator, the crystal is cut and mounted between two metallic plates.



The crystal behaves like R-L-C circuit due to:

- A low-valued Resistor R.
- A large valued inductor L.
- A small valued capacitor C_1.

Due to presence of C_2 the crystal will resonate at two frequencies:

1. Series resonant frequency - It occurs when C_1 resonates with L, thereby leading to least impedance and largest amount of feedback.

$$f_s = \frac{1}{2\pi\sqrt{LC_1}}$$

2. Parallel resonant frequency - It occurs when the resistance of LC_1 equals the resistance of C_2, thereby leading to highest impedance and least feedback.

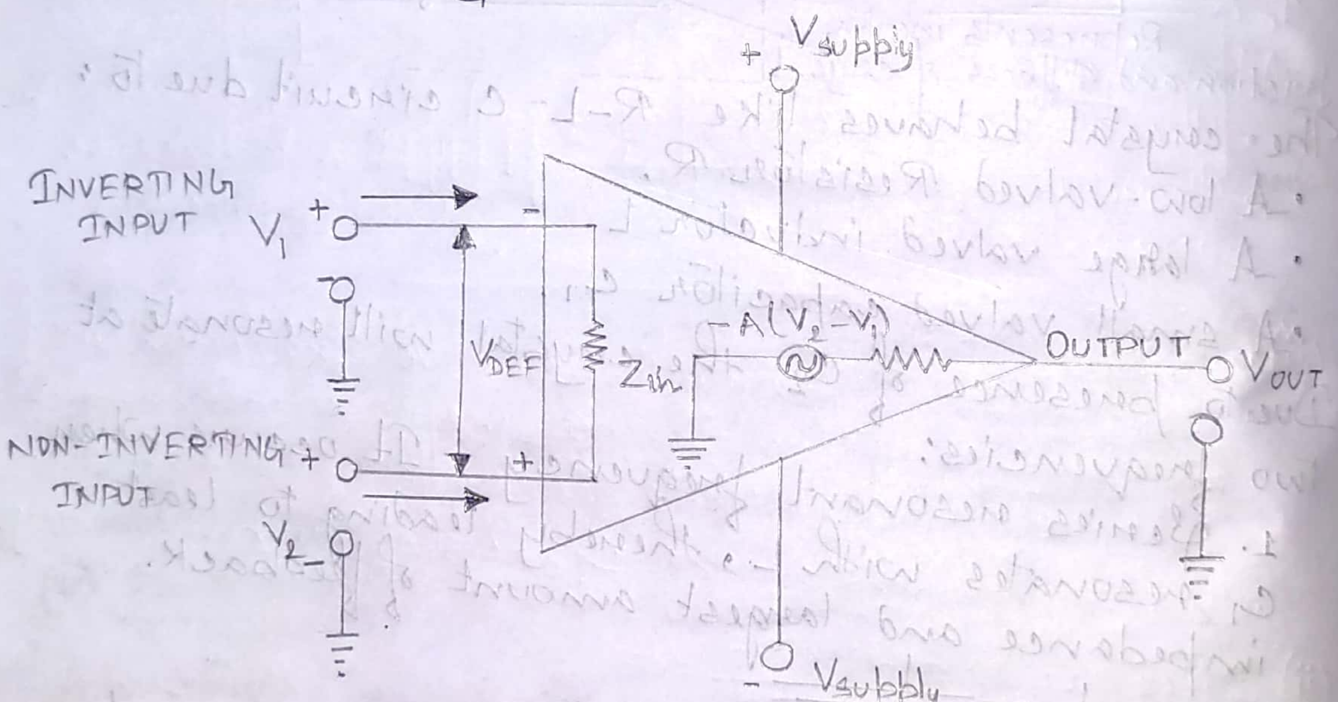
$$f_P = \frac{1}{2\pi\sqrt{L \cdot \frac{C_2 C_1}{C_2 + C_1}}}$$

Crystal oscillators offers low impedance in series resonant mode and high impedance in parallel resonant mode.

5. Explain the ideal operational amplifier.

Sol^n. The ideal operational amplifier is an amplifier with infinite input impedance, infinite-loop gain, zero output impedance, infinite bandwith and zero-noise. It has positive and negative inputs which allow circuits that use feedback to achieve a wide range of functions.

The effect voltage of operational amplifier in ideal case is zero.



EQUIVALENT CIRCUIT OF AN IDEAL OPERATIONAL AMPLIFIER