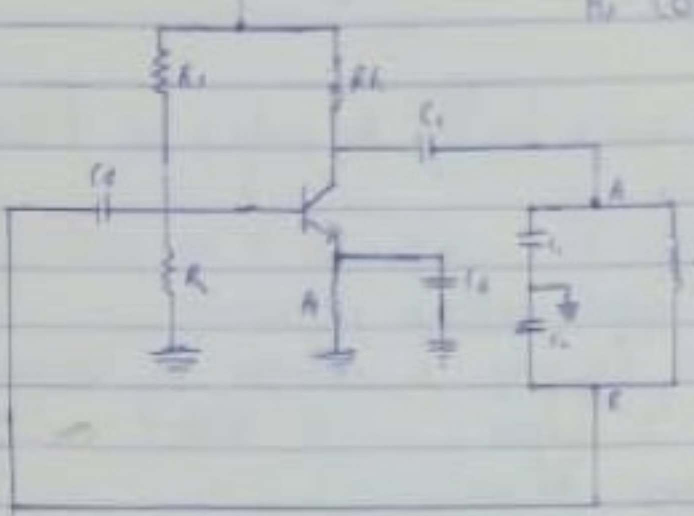
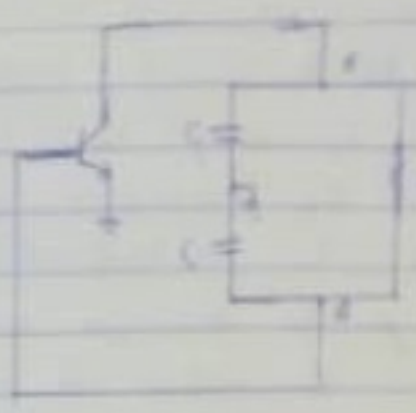
The Colpitts Oscillator





Colpitts Oscillator is an electronic oscillator which uses an inductor and capacitor to form a LC oscillator circuit. It is much similar to the Hartley oscillator except the addition of tank circuit. In colpitts oscillator the tank circuit consists of two capacitors in series and an inductor connected in parallel to the ~~inductor~~ series combination.

Fig a: In the circuit diagram resistor R_1 and R_2 gives a voltage divider biasing to the transistor. Resistor R_C limits the collector current of the transistor. C_{in} is the input DC decoupling capacitor while C_e is the output decoupling capacitor. R_E is the emitter resistor and it mounts for thermal stability. C_E is the emitter bypass capacitor. Job of the emitter by-pass capacitor is to by-pass the amplified AC signals from dropping across R_E. The emitter by-pass capacitor is not there, the amplified AC signal will drop across R_E and it will alter the DC biasing condition of the transistor and the result will be reduced gain. Capacitor C_1, C_2 and inductor L_1 forms the tank circuit. Feedback to the base of transistor is taken from the junction of capacitor C_2 with inductor L_1 in the [illegible]

i. Feedback fraction $\beta = C_1/C_2$

The oscillator to start, the voltage gain (A_v) must be greater than $1/\beta$ (C_2/C_1) i.e. otherwise $A_v > C_2/C_1$. The frequency of oscillation (neglecting mutual [illegible]) is given by the relation $F_0 = \frac{1}{2\pi\sqrt{LC}}$

where C is the effective value of capacitance and equal to

$$\frac{C_1 \times C_2}{C_1 + C_2}$$

$f_o = \frac{1}{2\pi\sqrt{L \times \frac{C_1 C_2}{C_1+C_2}}}$

1. For the Colpitts oscillator in 'a' above having the values of L = 40mH, $C_1 = 100pF$ and $C_2 = 500pF$. Find
i. The frequency of oscillation
ii. The feedback voltage if the input voltage is 10v
iii. The minimum gain if the frequency is changed by changing the value of the inductor 'L' above
iv. The value of C_2 for a gain of 10
v. The new frequency of the oscillation for the "iv" above

Solution

$L = 40mH = 40 \times 10^{-3} H$
$C_1 = 100pF = 100 \times 10^{-12}$, $C_2 = 500pF = 500 \times 10^{-12} F$

i. Frequency of oscillation =

$$f_o = \frac{1}{2\pi\sqrt{LC_{eq}}}$$

$$C_{eq} = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{((100 \times 10^{-12}) \times (500 \times 10^{-12}))}{((500 \times 10^{-12}) + (100 \times 10^{-12}))}$$

$$= 83.33 \times 10^{-12} F$$

$$\therefore f_o = \frac{1}{2\pi\sqrt{40 \times 10^{-3} \times 83.33 \times 10^{-12}}}$$

$$= 87.173 \; KHz$$

ii. The feedback voltage = $\frac{V_o}{gain}$

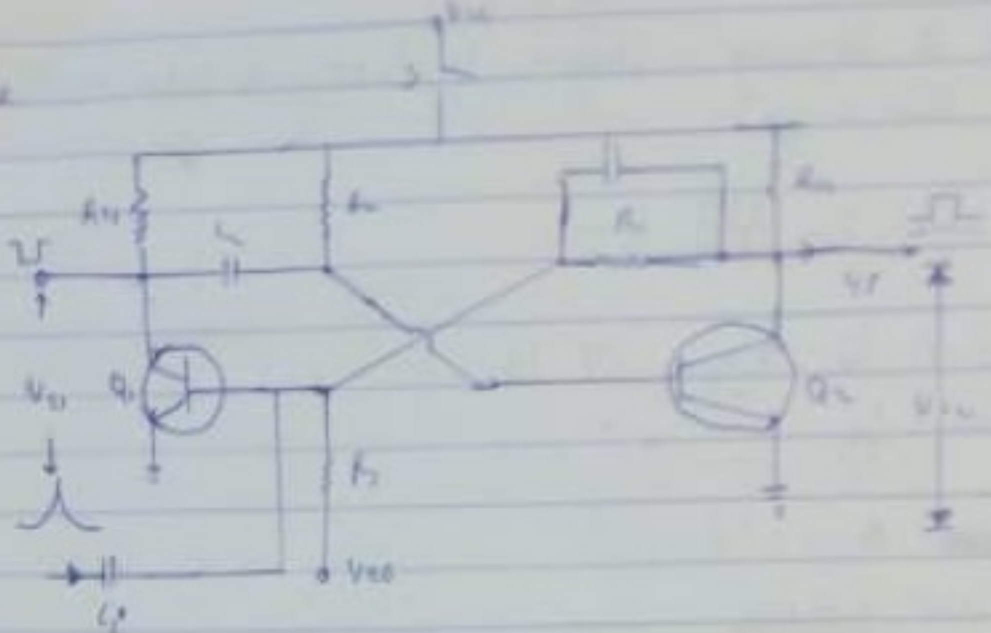
$V_o = 10v$

$Gain = \frac{C_2}{C_1} = \frac{500}{100} = 5$

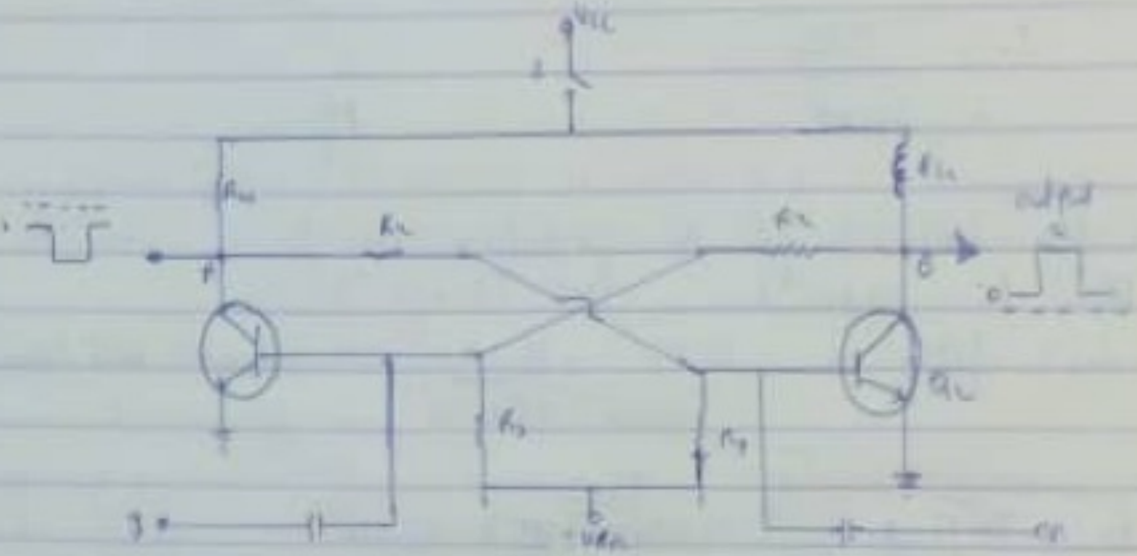
Feedback voltage = $\frac{10}{5}$

$= 2v$

Monostable



Bistable



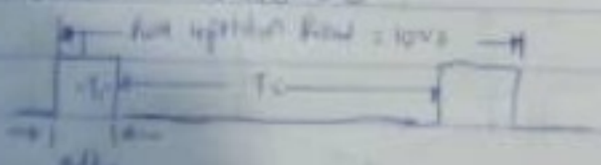
1. Calculate the value of the capacitor to be used in an astable multivibrator to provide a train of pulse 1 μsec wide at a repetition rate of 100kHz. Given $R_1 = R_2 = 10k\Omega$

Answer

Pulse width = 1 μsec = 1×10^{-6} sec f = 100kHz = 100×10^3 Hz

$R_1 = R_2$ = $10k\Omega$ = $10\times10^3\ \Omega$

Using the diagram



Frequency of oscillation (f) = $\frac{1}{T}$

$100\times10^3 = \frac{1}{T}$

iii. Minimum gain, if the frequency is changed by changing the ...

$$Gain = \frac{C_2}{C_1}$$

$$= \frac{500}{100} = 5$$

iv. The value of C_1 for a gain of 10

$$Gain = \frac{C_2}{C_1}$$

Gain = 10

$$10 = \frac{500 \times 10^{-12}}{C_1}$$

$$C_1 = \frac{500 \times 10^{-12}}{10}$$

$$= 50pf$$

v. The new frequency of the oscillation for the '10' above

When $C_1 = 50 \times 10^{-12}F$, $C_2 = 500 \times 10^{-12}F$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{50 \times 10^{-12} \times 500 \times 10^{-12}}{50 \times 10^{-12} + 500 \times 10^{-12}} = 45.455 \times 10^{-12}F$$

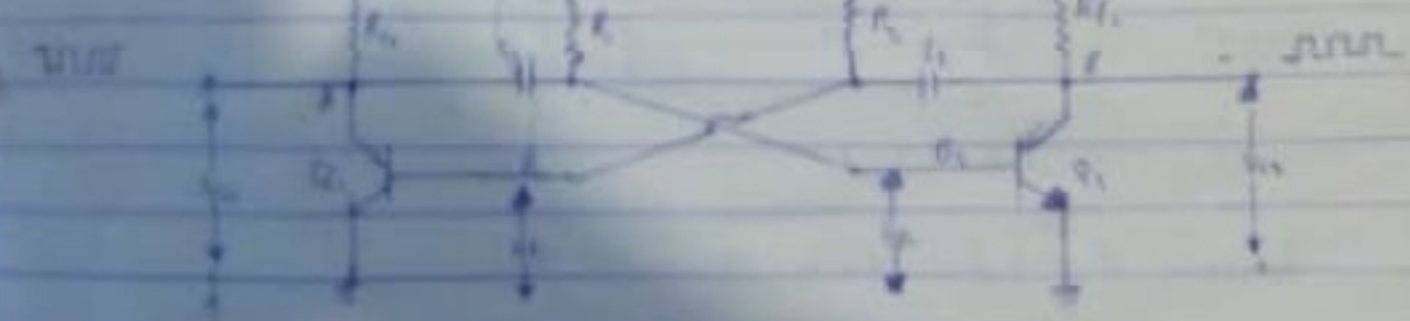
$$f = \frac{1}{2\pi\sqrt{LC_{eq}}} = \frac{1}{2\pi\sqrt{45.455 \times 40 \times 10^{-3}}}$$

$$= 118kHz$$

Question 2.

a. Draw the circuit diagram of Astable, Monostable and Bistable multivibrator

Astable Multivibrator



t_c - value of capacitor

$T = \frac{1}{100 \times 10^3} = 10 \times 10^{-6}$ sec

width (t_1) = $1 \times 10^{-6} = 0.69 R_1 \cdot C_1$

$C_1 = \frac{1 \times 10^{-6}}{0.69 \times 10 \times 10^3}$

$= 145 \times 10^{-12}$ f

$= 145$ pf

Period (T),

$10 \times 10^{-6} = T_1 + T_2$

$= 1 \times 10^{-6} + T_2$

$T_2 = 10 \times 10^{-6} - 1 \times 10^{-6}$

$= 9 \times 10^{-6}$ sec

$\therefore T_2 = 0.69 R_2 \times C_2$

$C_2 = \frac{T_2}{0.69 R_2}$

$C_2 = \frac{9 \cdot 10^{-6}}{0.69 \times 10 \times 10^3}$

$= 1304 \times 10^{-12}$ f

$= 1304$ pf

c. Calculate the input pulse width for a monostable multivibrator for the design values of $R_1 = 2k\Omega$, $R_2 = 20k\Omega$, $C = 0.1\mu f$ and $V_{cc} = 12V$. Assume $V_{BE(sat)} = 0.2V$, $V_{CE(sat)} = 0.4V$ and $\beta = 50$

Solution

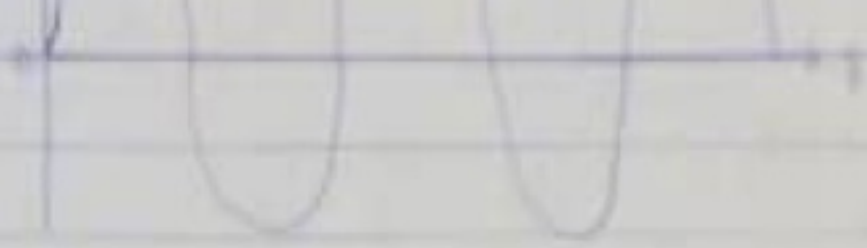
$V_{cc} = 12V$

Input pulse width,

$T = RC \log_e \frac{2V_{cc} - V_{CE(sat)}}{V_{cc} - V_{CE(sat)}}$

$= 22 \times 10^3 \times 0.1 \times 10^{-6} \log_e \frac{2 \times 12 - 0.4}{12 - 0.4}$

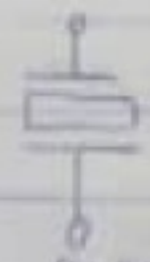
$= 1.6565$ msec



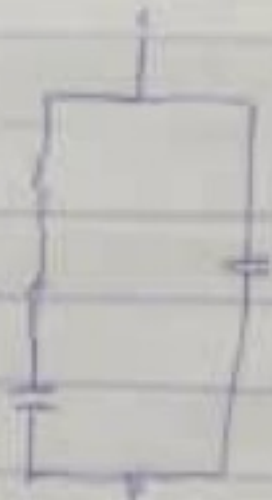
c. Explain briefly the transistor pierce crystal oscillator using appropriate circuit

Answer

A Crystal Oscillator : It is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a precise frequency. These oscillators use quartz crystals and are used to generate highly stabilized output signal with frequency up to 10MHz. The pierce oscillator is an crystal oscillator



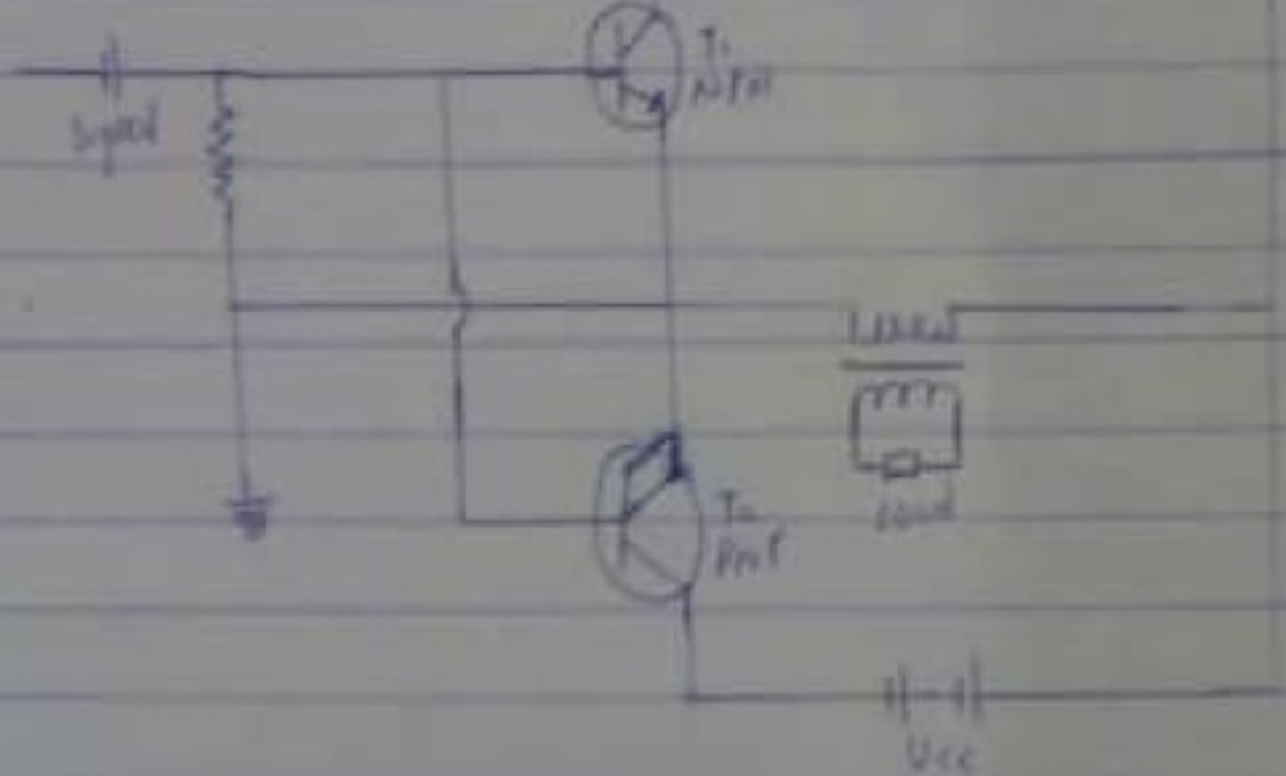
the symbol



	[illegible] response of the signal	[illegible]
Function	An amplifier is used repeatedly in a circuit because the signal loses its intensity after travelling to a long distance	An oscillator is used only at the start stage where the carrier [illegible] signal
Feedback	It uses negative feedback	It uses positive feedback
Requirement of input	The input is required for its operation. It cannot operate without input	It does not require any input for its operation
Type of signal generated	The signal can be periodic or non-periodic	The signal generated by it will be always periodic in nature

2) Explain the following briefly

Damped Oscillation



The circuit above employs an NPN transistor and a PNP transistor connected in push pull configuration. When the input signal is applied, during the positive half cycle of the input signal, the NPN transistor conducts and the PNP transistor cut off. During the negative half cycle, the NPN transistor cuts off and the PNP transistor conducts.

This way the NPN transistor amplifies during positive half cycle of the input while PNP transistor amplifies during negative half cycle of input. As the transistors are both complement to each other, [illegible] symmetrically [illegible] being connected in push pull configuration of class B.

$= \frac{1}{2\pi\sqrt{[illegible]}} = 720 \text{ KHz}$

c. Parallel resonant frequency

$$f_p = \frac{1}{2\pi\sqrt{L C_{eq}}}$$

$$C_{eq} = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{0.05\times10^{-12} \times 1\times10^{-12}}{0.05\times10^{-12} + 1\times10^{-12}}$$

$$= 0.047\times10^{-12} F$$

$$f_p = \frac{1}{2\pi\sqrt{0.5\times0.047\times10^{-12}}}$$

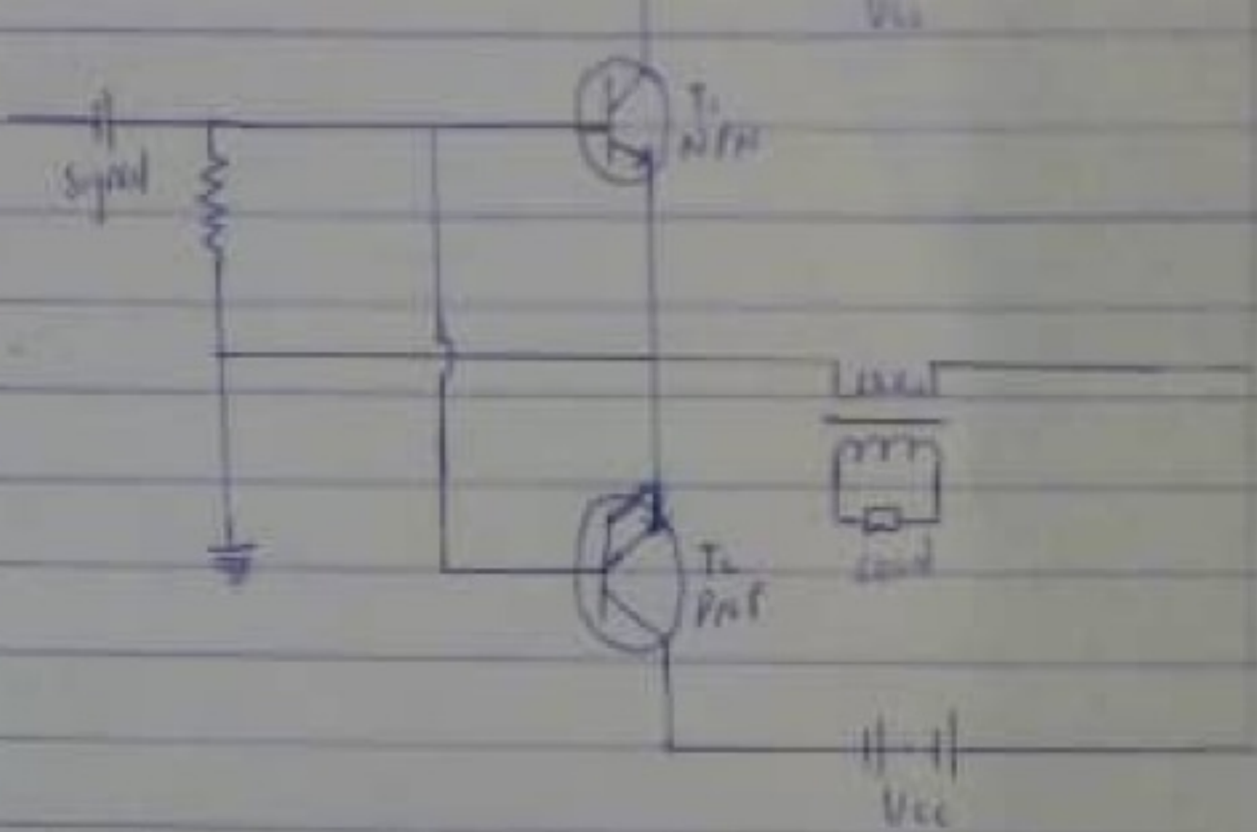
$$= 992 \text{ KHz}$$

Q - Factor of the crystal

$$Q = \frac{2\pi f_s L}{R}$$

$$= \frac{2\pi \times 720 \; 41\times10^{6} \; [illegible]}{5\times10^{3}}$$

$= 577.$



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In this way the NPN transistor amplifies during positive half cycle of the input while PNP transistor amplifies during negative half cycle of input. As the transistors are both complement to each other, yet act