Electronic principles and circuits Module 1 notes

Electronic principles and circuits (Visvesvaraya Technological University)

||Sell|| EP&C → M_3 - 1

Linear op-amp circuits :- [Voltage amplifiers, Current sources & active filters]

Summing Amplifier :-

The main function of summing amplifier is to amplify the sum of two input signal.

→ Whenever we need to combine two or more analog signals into single output, the summing amplifier is used.

→ Let consider that when ckt is having a two input signals, then gain of each input is given by the ratio of feedback resistance to the appropriate input resistance.

$$A_{CL_1} = \frac{R_F}{R_1} \quad \& \quad A_{CL_2} = \frac{R_F}{R_2}$$

The summing circuit combines all the amplified input signals into a single output signals.

$$\boxed{\therefore V_{out} = A_{CL_1} V_1 + A_{CL_2} V_2}$$

Substractor :-

The ckt that substract two input voltages to produce an output voltage equal to the difference of V_1 & V_2.

$$\boxed{V_{out} = V_1 - V_2}$$

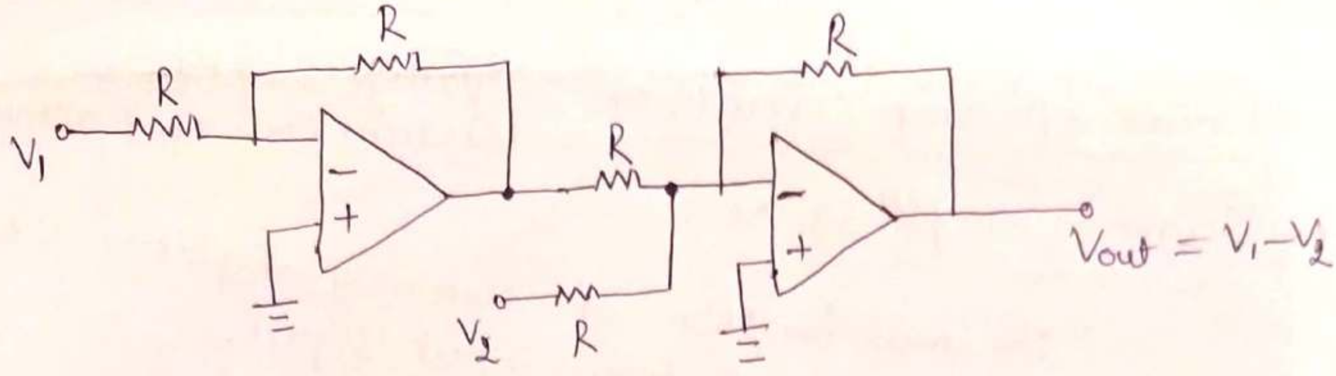


Fig. Substracter.

→ In the above ckt input V_1 drives an inverter with a voltage gain of unity, hence o/p of first stage is $-V_1$. This voltage is one of the inputs to the second-stage summing circuit.

→ The other i/p is V_2. Since the gain of each channel is unity, the output voltage is

$$\boxed{V_0 = V_1 - V_2}$$

Summing on both Inputs

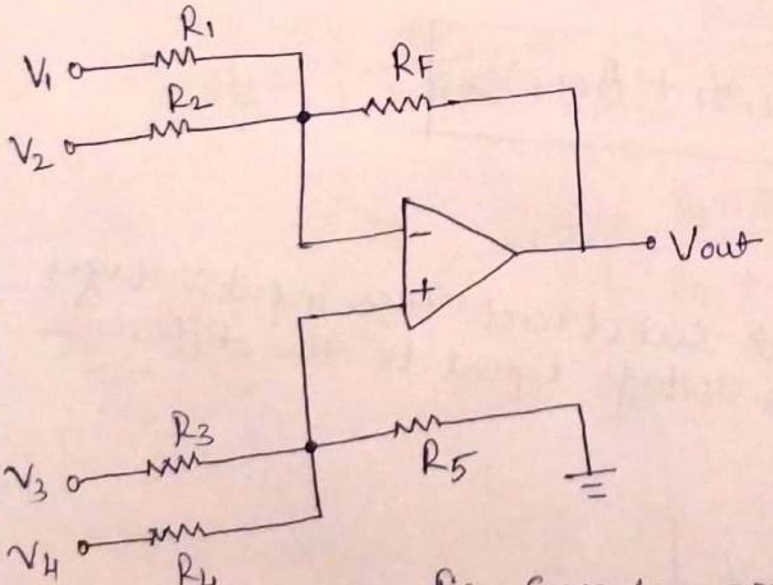


fig. Summing amplifier using both sides of op-amp.

Let consider a summing ckt that consist of two input terminal i.e. Inverting and noninverting input terminals.

→ The inverting side of amplifier has two input channels & the non inverting side has two input channels.

→ The gain of each inverting channel is the ratio of feedback resistor R_F to input channel resistance R_1 or R_2

$$\therefore \quad A_1 = \frac{-R_F}{R_1}$$

$$\& \quad A_2 = -\frac{R_F}{R_2}$$

lly the gain of each non inverting channel is

$$A_3 = \left[\frac{R_F}{R_1 \| R_2} + 1\right]\left[\frac{R_4 \| R_5}{(R_3 + R_4) \| R_5}\right]$$

$$A_3 = \left[\frac{R_F}{R_1 \| R_2} + 1\right]\left[\frac{R_4 \| R_5}{R_3 + R_4 \| R_5}\right]$$

$$A_4 = \left(\frac{R_F}{R_1 \| R_2} + 1\right)\left(\frac{R_3 \| R_5}{R_4 + R_3 \| R_5}\right)$$

$$\frac{R_F}{R_1 \| R_2} + 1$$

By using Voltage divider

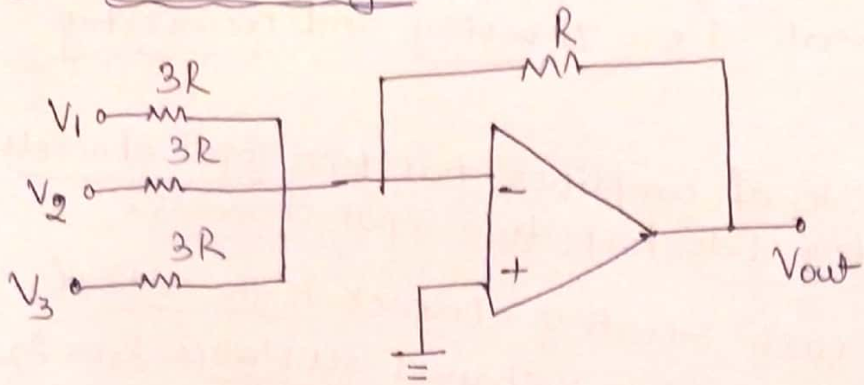
$$\Rightarrow \frac{R_4 \| R_5}{R_3 + R_4 \| R_5}$$

$$\Rightarrow \frac{R_3 \| R_5}{R_4 + R_3 \| R_5}$$

The output voltage of ckt is given by.

$$\boxed{V_{out} = A_1 V_1 + A_2 V_2 + A_3 V_3 + A_4 V_4.}$$

The averager



$$\boxed{V_{out} = -\frac{[V_1+V_2+V_3]}{3}}$$

- The circuit whose output equals to the average of input voltages.

Each channel has a voltage gain of

$$\boxed{A_V = \frac{R}{3R} = \frac{1}{3}}$$

→ when all the amplified outputs are added, we can get average of all i/p voltages.

→ Any number of inputs can be used, as long as each channel input resistance is changed to nR, where n is number of channels

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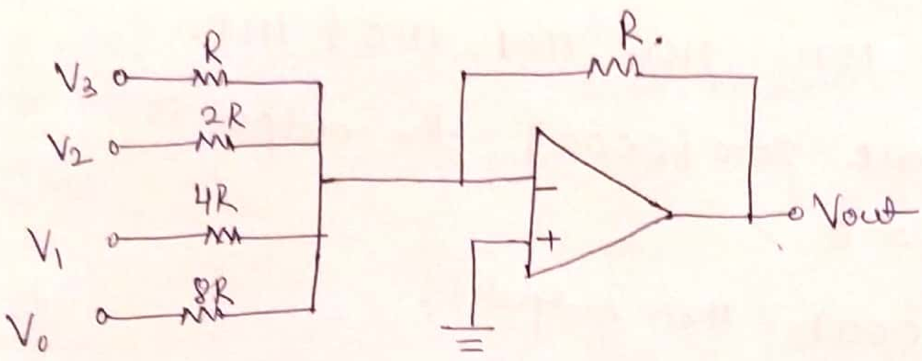
D/A converter :-



$A = \frac{-R_f}{R} = \frac{-R}{R} = -1$

$A = -\frac{R}{2R} = -0.5$

$A = -\frac{R}{4R} = -0.25$

$A = \frac{-R}{8R} = -0.125$

Fig: D/A converter changes digital I/p to analog voltage.

→ D/A converter is a weighted summing ckt that produces an output equal to the weighted sum of inputs.

→ The weight is same as that of gain of channel.

→ In the above fig the channel gains are

$A_3 = -1$

$A_2 = -0.5$

$A_1 = -0.25$

$A_0 = -0.125$

→ In the above fig it is having digital inputs i.e. 1 or 0. & it is having 4 inputs hence it consist of 16 possible input combinations of $V_3 V_2 V_1 V_0$.

The digital inputs are $V_3 V_2 V_1 V_0 \Rightarrow$

0000, 0001, 0010, 0011, 0100, 0101, 0110, 0111, 1000, 1001, 1010, 1011, 1100, 1101, 1110 & 1111.

when all inputs are Zero [0000], the output is

$$V_{out} = 0$$

when $V_3 V_2 V_1 V_0 = 0001$, then output is

$$V_{out} = -[0.125] = -0.125$$

when $V_3 V_2 V_1 V_0 = 0010$ then output is

$$V_{out} = -[0.25] = -0.25$$

when all i/p are 1' i.e. 1111 then o/p is maximum

$$\therefore V_{out} = -[1 + 0.5 + 0.25 + 0.125]$$

$$\boxed{V_{out} = -1.875}$$

$$\boxed{\therefore V_{out} = -[V_3 + 0.5 V_2 + 0.25 V_1 + 0.125 V_0]}$$

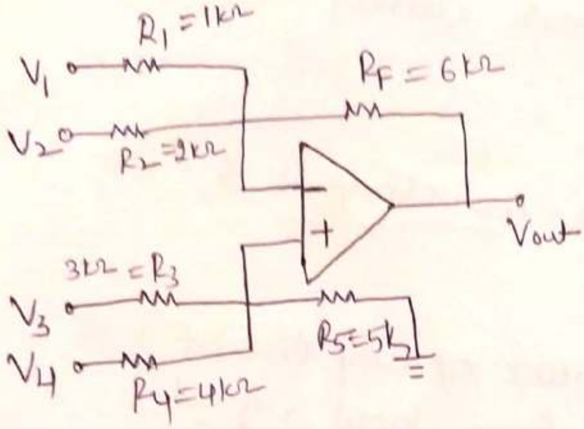
→ A 4 i/p D/A converter has 16 possible outputs.

→ A 8 i/p " " " 256 " "

→ A 16 i/p " " " 65,536 " "

✪ Problem 8:

For the ckt shown below what is the voltage gain of each channel.



Soln :– $A_1 = -\dfrac{R_F}{R_1}$

$$A_1 = -\frac{6k\Omega}{1k\Omega} = -6$$

$$A_2 = \frac{-R_F}{R_2} = \frac{-6k\Omega}{2k\Omega} = -3$$

$$A_3 = \left[\frac{R_F}{R_1 \| R_2} + 1\right]\left[\frac{R_4 \| R_5}{R_3 + R_4 \| R_5}\right]$$

$$= \left[\frac{6k\Omega}{1k\Omega \| 2k\Omega} + 1\right]\left[\frac{4k\Omega \| 5k\Omega}{3k\Omega + 4k\Omega \| 5k\Omega}\right]$$

$$\boxed{A_3 = 4.26}$$

$$A_4 = \left[\frac{R_F}{R_1 \| R_2} + 1\right]\left[\frac{R_3 \| R_5}{R_4 + R_3 \| R_5}\right]$$

$$= \left[\frac{6k\Omega}{1k\Omega \| 2k\Omega} + 1\right]\left[\frac{3k\Omega \| 5k\Omega}{4k\Omega + 3k\Omega \| 5k\Omega}\right]$$

$$\boxed{A_4 = 3.19}$$

Non linear op-amp circuits :-

Linear ckts :- Voltage amplifiers, current sources, and active filters.

Non linear ckts :- Comparator, waveshapers & active diode circuits.

The output of a nonlinear op-amp circuit usualy has a different shape from input signal because the op-amp saturates during part of i/p signal or cycle.

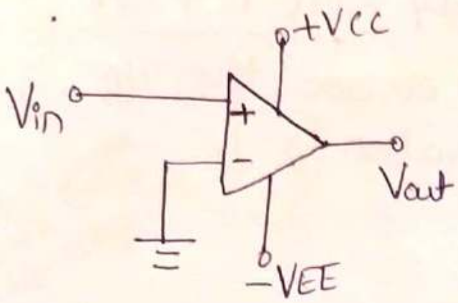
Comparator with Zero Refference :-

⇒ Comparators are the circuit which is used to compare one voltage with another voltage.

comparators are similar to an op-amp because it has two input voltages [NI & INV] and one o/p Voltage i.e. either low or High. [0 or 1].

⊛

Basic Idea :-



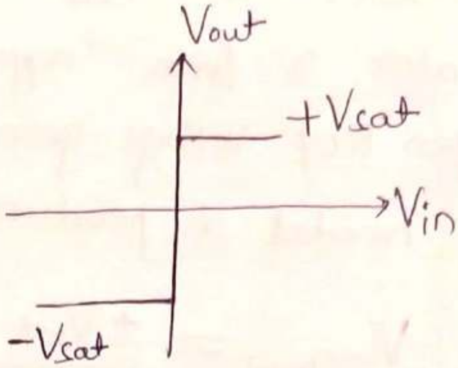


Fig. (a) Comparator (b) I/O Response.

→ When we are connecting op-amp without feedback resistor then circuit results in comparator. Due to high open-loop voltage gain, a positive input voltage producess a positive saturation, & negative input voltage producess negative saturation.

→ The above ckt is also called as zero-crossing-detector because the output voltage idealy switches from low to high or vice versa whenever input voltage crosses zero.

Fig. (b) The input-output response of a zero crossing detector as shown in fig.

⇒ The minimum input voltage that producess a saturation is

$$\boxed{V_{in(min)} = \frac{\pm V_{sat}}{A_{OL}}}$$

where,

A_{OL} → openloopgain.

Let consider if $V_{sat} = 14V$, then o/p swing of comparator is from approximately $-14V$ to $+14V$. if open loop Voltage gain is 1,00,000 the i/p Voltage needed to produce saturation is

$$V_{in(min)} = \frac{\pm V_{sat}}{A_{OL}}$$

$$= \frac{\pm 14V}{100\,000}$$

$$\boxed{V_{in(min)} = \pm 0.014mV}$$

→ From above Value we can say that when i/p Voltage more positive than $+0.014mV$ drives the comparator into positive saturation. & when $-0.014mV$ drives into Negative saturation.

Lissajous pattern :-

It appears on an oscilloscope when harmonically related signals are applied to the horrizontal & Vertical Inputs.

Inverting Comparator :-

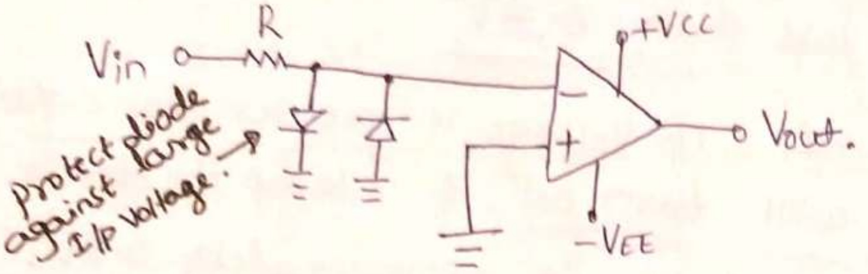


Fig. ⓐ Inverting comparator with Clamping diode.

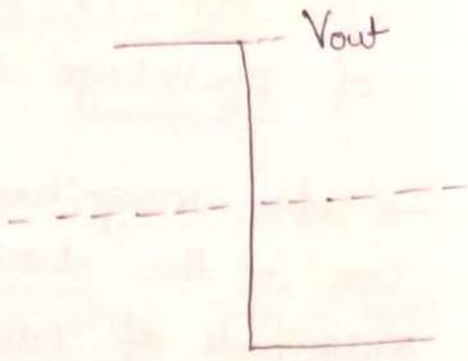


Fig. ⓑ Input/output.

→ Inverting comparator is a ckt in which we are applying input to INV terminal of comparator & NI terminal is connected to ground.

→ As we are applying +ve voltage I/p to INV terminal hence it producess a maximum negative output.
& -ve i/p Voltage producers a maximum +ve output.

Diode Clamps :-

→ In the above ckt we are using diode clamps, the main function of diode clamp is to protect the comparator against excessively large input voltage.

→ Ex :- IC LF311 is an IC comparator it is having maximum I/p rating of ± 15V, If I/p Voltage exceeds 15V, LF311 will be destroyed.

→ Some comparators are having rating of ± 5V, ± 30V,

→ The diodes are not having any effect on operation of circuit as long as the magnitude of I/p Voltage is less than 0.7V

→ when magnitude of i/p Voltage is greater than 0.7V One of the diode will turn ON & clamp the ~~diode~~ magnitude of INV I/p Voltage to approximately 0.7V.

Converting sine wave to square wave :-

Threshold point / Ref. point / Trip point :- It is an input voltage that causes the output voltage to switch states from low to high & High to low.

→ Zero crossing detector has two output states, any periodic I/p signal that crosses zero threshold will produce a rectangular o/p waveform.

Ex If a sine wave is a I/p to NI comparator with a threshold of 0V, the o/p will be square wave. from below fig we can say that the o/p of Zero crossing detector switches states each time the input voltage crosses the Zero threshold.

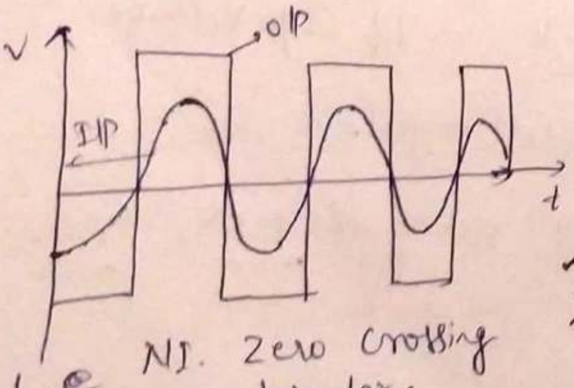


fig (a) NI. Zero crossing detector.

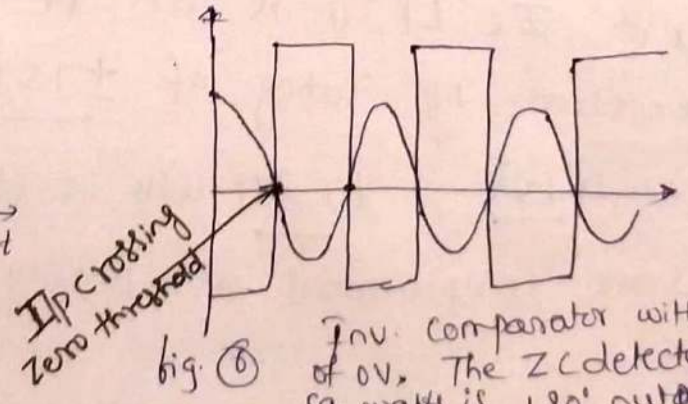
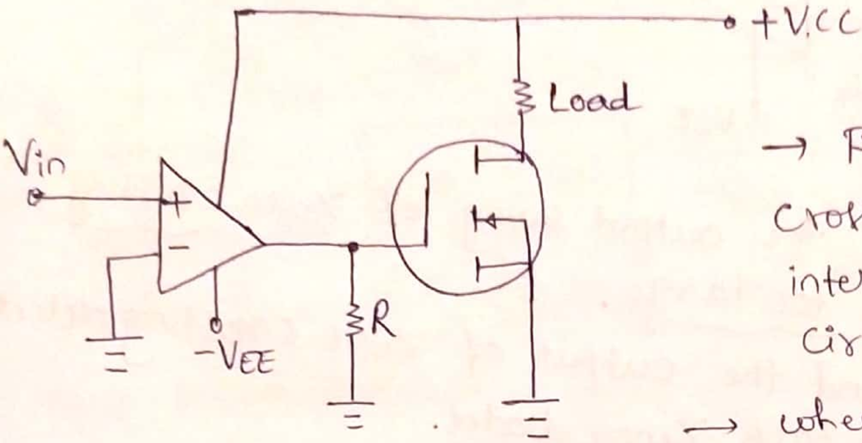


fig (b) Inv. comparator with threshold of 0V. The ZC detector the o/p sq. wave is 180° out of phase with I/p sine wave

⊛ Interfacing Analog & Digital Circuits :-

⇒ Comparators usualy interface at their o/p with digital ckt. such as CMOS, EMOS & TTL.



→ Fig. shows how a zero crossing detector can interface with an EMOS circuit.

→ when I/p voltage greater than zero, the o/p of comparator is high. This turns ON the power FET & produces a large load current.

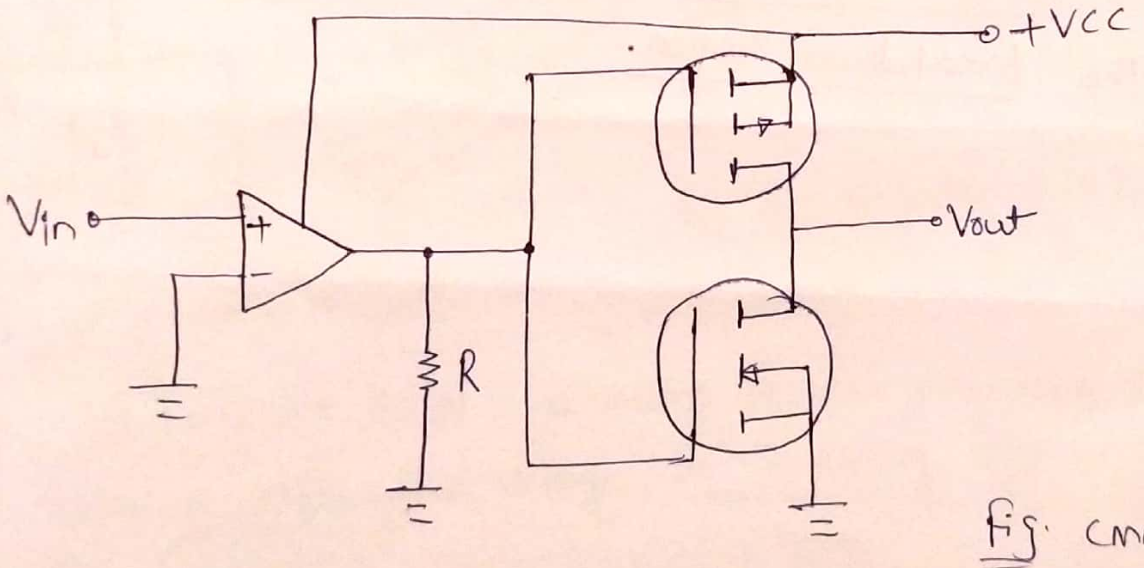
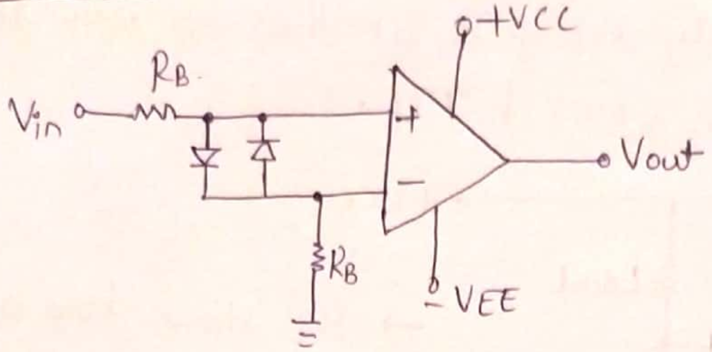


Fig. CMOS

→ Above fig shows zero crossing detector interfacing with a CMOS inverter. A comparator i/p greater than zero produces a high I/p to CMOS inverter.

Bounded output g_r



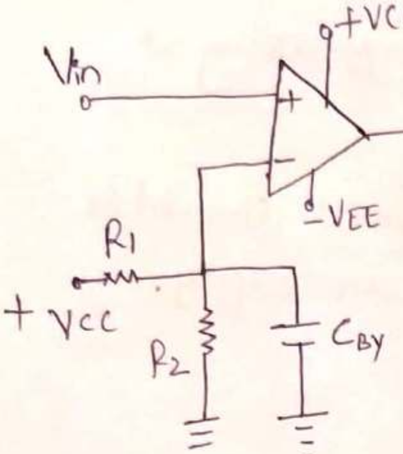
→ In some cases the output swing of zero crossing detector may be too large.

we can bound the output of zero crossing detector by using back to back Zener diodes.

→ In the above fig the INV comparator has bounded output because one of the diode will be conducting in the forword direction & other will be operating in the breakdown region.

⊛ Comparators with Nonzero References :-

Key points
- Ref voltage at INV $V_{ref} = \frac{R_2}{R_1+R_2} V_{CC}$.
- when $V_{in} > V_{ref} \Rightarrow$ Diff I/p is +ve & V_0 = high
- when $V_{in} < V_{ref}$ = I/p –ve & V_0 = low



$$V_{ref} = \frac{R_2}{R_1+R_2} V_{CC}$$
$$f_c = \frac{1}{2\pi (R_1 \| R_2) C_{BY}}$$

Fig. ⓐ positive threshold.

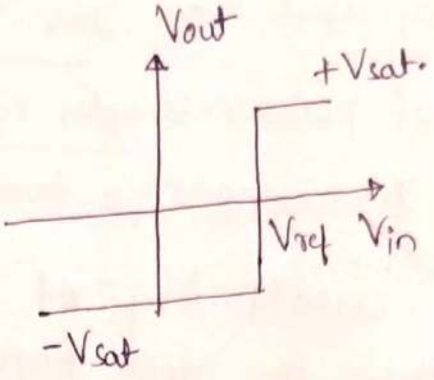


Fig. ⓑ positive I/O response.

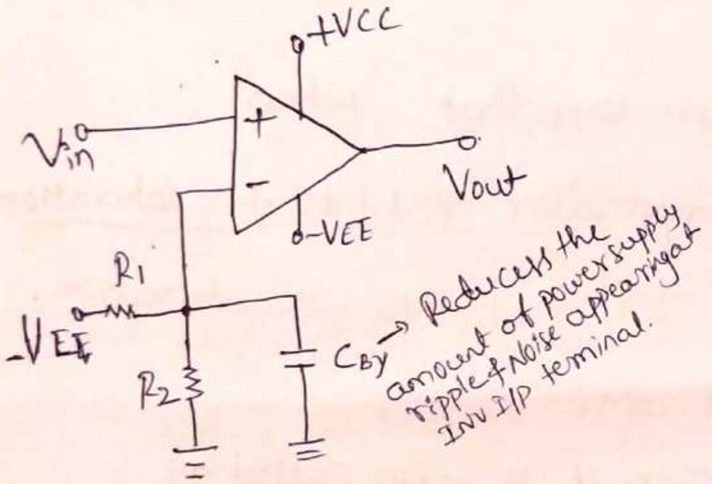


fig. ⓒ Negative threshold.

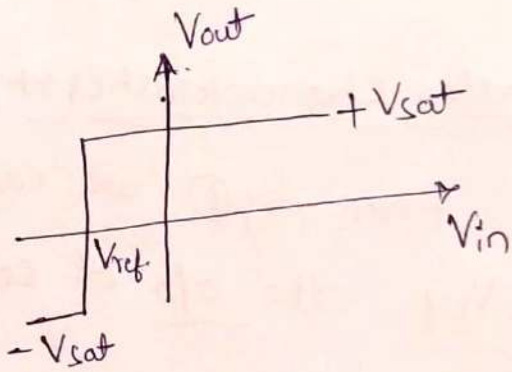


fig. ⓓ Negative I/O Response.

Let consider fig ⓐ, a voltage divider producess the following refference voltage for inverting I/P.

$$V_{ref} = \frac{R_2}{R_1+R_2} V_{CC}.$$

Note:- ① when $V_{in} > V_{ref}$, The differential I/p voltage is +ve & the o/p is high.

② when $V_{in} < V_{ref}$, The diff I/p voltage is –ve & O/p is low.

→ In the above circuit diagram a bypass capacitor is typicaly used on Inv I/P terminal, it will reducess amount of power supply ripple & noise appearing at ~~Inverting~~ Inverting I/p terminal.

→ The cutoff freq. of bypass capacitor should be lower than the ripple frequency of power supply.

$$\therefore f_c = \frac{1}{2\pi (R_1 \| R_2) C_{BY}}.$$

Transfer characteristics:-

From fig.ⓑ we can say that, when

$V_{in} > V_{ref}$, the o/p of comparator goes into +ve saturation.

$V_{in} < V_{ref}$, the " " " into −ve saturation.

→ The above comparator circuit is also called as limit detector because +ve o/p indicates that the input voltage exceeds a specific limit with different values of R_1 & R_2, we can set the limit anywhere betn 0 & VCC.

⇒ when a −ve reference voltage is applied to the INV. I/P when V_{in} is more positive than V_{ref}, the differential I/P voltage is +ve & o/p is high.

→ when V_{in} is more −ve than V_{ref}, o/p is low.

⊛ Single supply comparator

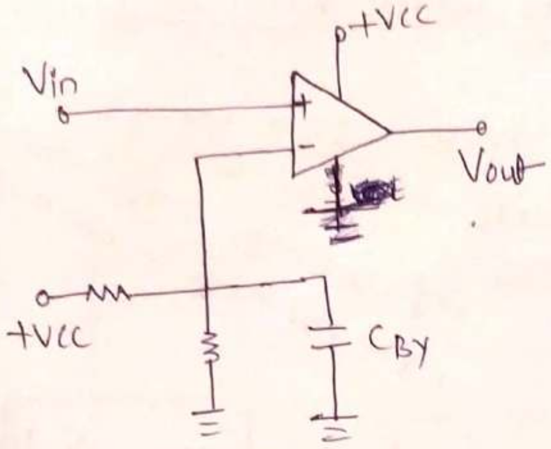


fig. @ Single supply comparator

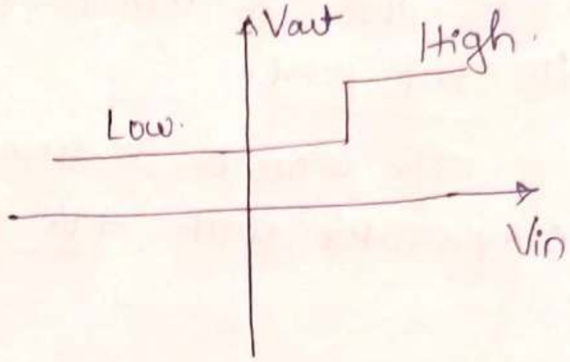


fig: I/O Response.

→ A single supply comparator is a ckt in which -VEE pin is directly connected to ground.

→ Here the o/p Voltage has only the polarity either a low or high positive voltage.

→ Let consider when $V_{CC} = 15V$ then o/p swing is from approximately +1.5V (low state) to +13.5V (High state).

when $V_{in} > V_{ref} \Rightarrow V_o = \text{high}$ —

$V_{in} < V_{ref} \Rightarrow V_o = \text{low}$ —

Comparator with Hysteresis :-

→ when I/p to comparator contains large amount of noise, the o/p will be erratic when Vin is near the trip point.

The way to reduce the noise is by using a comparator with +Ve feedback.

$e^- \downarrow$ -ve voltage → up to down
$e^- \uparrow$ → +Ve voltage → down to up

Noise :-

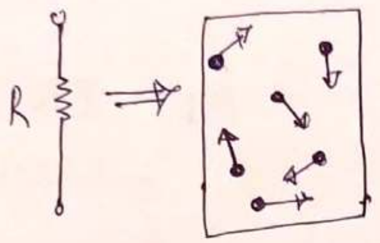


fig-a Random Electron motion in resistor

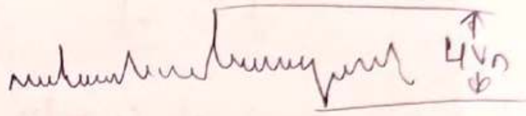


fig (b) Noise on oscilloscope.

⇒ Noise is anykind of unwanted signal.
The electric motors, neon signs, power lines, car Ignitions, lighting, etc produces an electromagnetic field that can induce a noise voltages into electronic ckts.
→ power supply ripple is also classified as noise.
By using regulated power supplies we can reduce the ripple & induced noise to an acceptable level.

Thermal noise :- The noise generated due to random motion of free electrons inside resistor.
The energy for this electron motion comes from the thermal energy of surroundings air.

→ when electrons move up than down, producing a small negative voltage across resistor. when electrons moves down than up producing a +ve voltage.
The randomness of electrons motion inside Resistor producess distribution of noise at virtualy all frequencies.

Schmitt Trigger :-

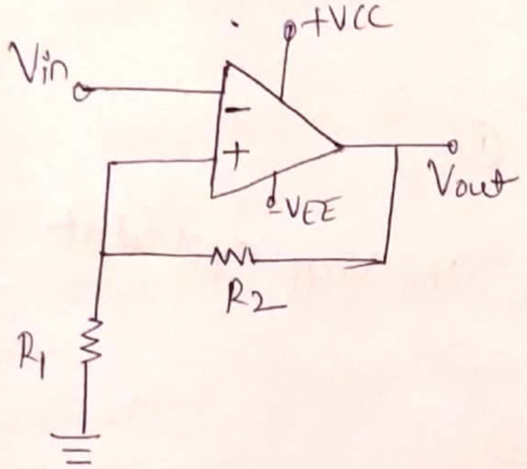
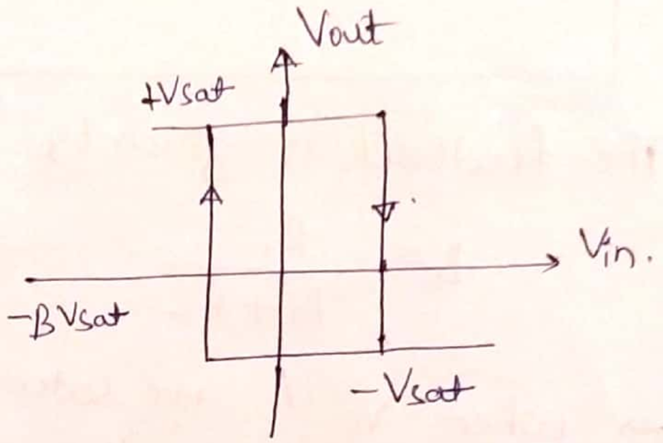


fig. INV Schimmit trigger



⑥ I/O response has Hysterisis.

→ Let consider above comparator ckt, in which we are applying i/p voltage to inverting input. Because the feedback voltage is aiding the i/p voltage, the feedback is +ve.

" Schimmit trigger :→ A comparator using +ve feedback is called as Schimmit trigger.

Working:→ when comparator is +vely saturated, a positive voltage is fedback to NI i/p terminal. the +ve feedback holds o/p to high state.

→ when comparator is -vely saturated, a -ve Voltage is feedback to NI terminal, holding V_0 = low.

Comparator:-
+ve saturation ⇒ +ve feedback to NI ⇒ V_0 = +Ve
-ve " ⇒ -ve " " " ⇒ V_0 = -Ve

The feedback is given by

$$B = \frac{R_1}{R_1 + R_2} \quad \text{—— ①}$$

⇒ when V_0 is +ve saturated, the Vreff applied at NI i/p terminal is

$$V_{ref} = +BV_{sat} \quad \text{—— ②}$$

⇒ when o/p is -vely saturated

$$V_{ref} = -BV_{sat} \quad \text{—— ③}$$

Hysterisis :- The unusual response of Schimmit trigger is called as hysterisis.

Let consider fig ⑥. let consider the point $+V_{sat} = V_0$ now move slightly towords right side along horrizontal line then V_{in} is changing but $V_0 = +V_{sat}$.

→ when reached at corner of horrizontal line. then $V_{in} = +BV_{sat}$, then V_0 goes into transition region betn high & low states.

→ Now move finger down along vertical line, when it reaches to lower horrizontal line o/p voltage is negativly saturated & equal to $-V_{sat}$.

→ when finger reaches to lower left corner i.e. $V_{in} = -B_{sat}$, then o/p voltage goes into transition from low to high.

Here we are using two trip points.

$$UTP = BV_{sat}$$

$$\& \; LTP = -BV_{sat}.$$

The difference betn UTP & LTP is called as Hysterisis.

$$\boxed{H = UTP - LTP}$$

$$H = BV_{sat} - [-BV_{sat}]$$

$$\boxed{H = 2BV_{sat}}$$

Non inverting schimmit trigger:-

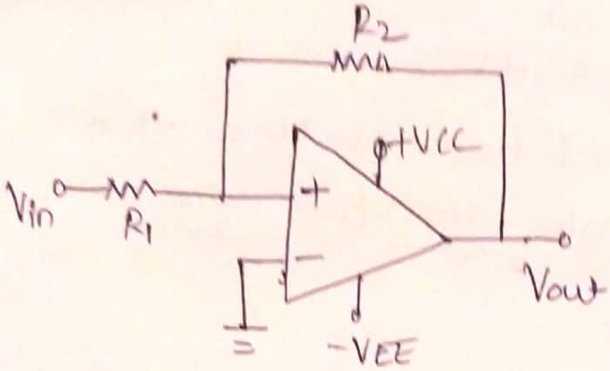


Fig. NI schimit trigger

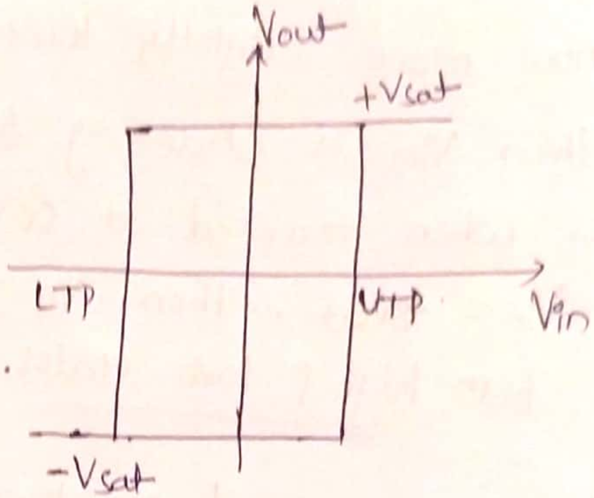


Fig. I/O Response.

→ when V_0 → +ly saturated, the feed back voltage to NI input is +ve. which results in positive saturation.

→ when V_0 → -vly saturated, the feedback to NI i/p is -ve which results in -ve saturation.

→ Here V_0 is at -ve saturation untill V_{in} becomes more +ve than UTP, but when $V_{in} > UTP$ then o/p switches from -ve to +ve saturation.

⇒ when V_0 = +ve saturation until $V_{in} < LTP$ when V_{in} is less than LTP, V_0 i.e. o/p Changes from again +ve to -ve saturation.

$$\boxed{\begin{aligned} UTP &= \frac{R_1}{R_2} V_{sat} \\ LTP &= -\frac{R_1}{R_2} V_{sat} \end{aligned}}$$

Oscillators :-

Theory of sinusoidal oscillation :-

The sinusoidal oscillator is build by using an amplifier with positive feedback.

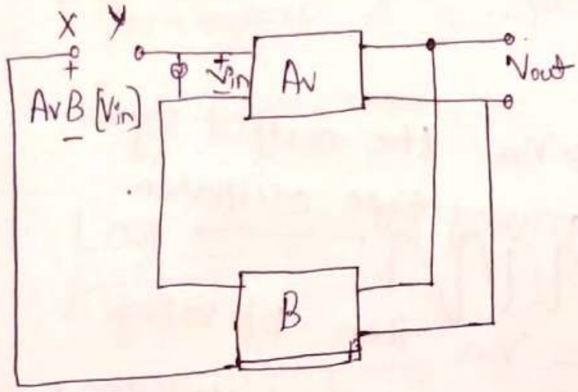


fig ⓐ Feedback voltage returns to point 'x'.

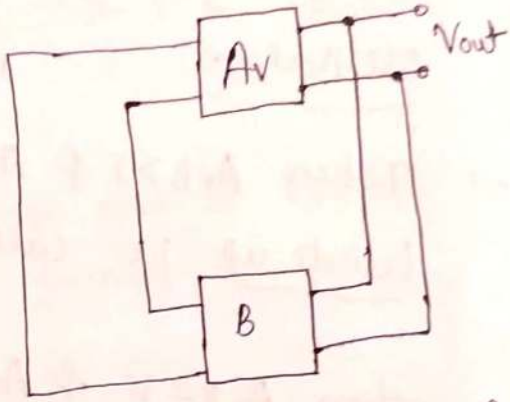


fig ⓑ connecting points X & Y

→ Let consider an ac source driving the input terminals of an amplifier. i.e. fig. ⓐ.

The amplified o/p voltage is given by

$$V_{out} = A_v (V_{in}) \quad \text{—— ①}$$

The feedback voltage returning to point 'x' is given by

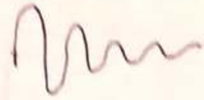
$$V_f = A_v B (V_{in}) \text{—} \quad ②$$

where B is called as feedback factor.

If phase shift through amplifier & feedback ckt is equivalent to 0°, $A_v B (V_{in})$ is in phase with Vin.

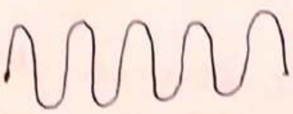
→ when we connect point 'x' to point 'y' & simultaniously remove voltage source Vin. Then feedback voltage $A_v B(V_{in})$ drives i/p of amplifier. i.e. fig ⓑ

→ If when $A_v B < 1$, & $A_v B(V_{in}) < V_{in}$ then o/p swing signal will die out, i.e. called as decaying oscillation.



→ When $A_v B > 1$ & $A_v B(V_{in}) > V_{in}$. the output signal builds up, i.e. called as growing type oscillation.

→ when $A_v B = V$ & $A_v B(V_{in}) = V_{in}$ then o/p voltage is steady sinewave i.e. called as sustained oscillation.



⊛ Starting voltage is thermal noise or

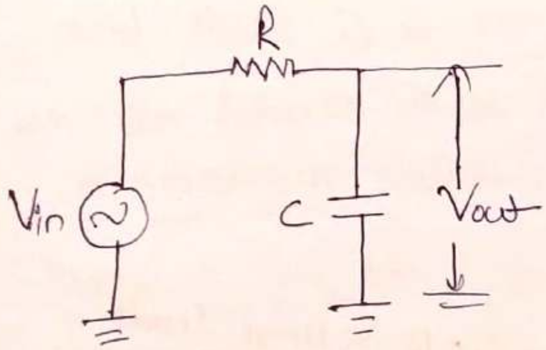
As we know that resistors contains free electrons, due to, due to ambient temperature, these free electrons move randomly in different directions. & generate noise voltage across resistors. The motion is so random that it contains frequencies to over 1000 GHz. Hence each resistor as a small ac voltage source producing all frequencies.

Wein bridge oscillator :-

→ Wein bridge oscillator circuit is a standard oscillator ckt for low to moderate frequencies, in the range of 5Hz to 1MHz.

→ It is almost always used in commercial audio generators & is usualy preffered for other low freq. applications.

Lag circuit :-



The voltage gain of by pass ckt is given by

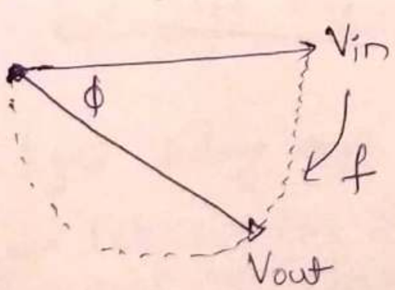
$$\frac{V_{out}}{V_{in}} = \frac{X_C}{\sqrt{R^2 + X_C^2}}$$

& phase angle

$$\phi = -\arctan \frac{R}{X_C}.$$

where ϕ is the phase angle between o/p & I/p.

where -ve sign indicates o/p voltage lags I/p voltage



→ In this fig. half circle shows the possible positions of o/p phaser voltage.

→ This indicates that o/p phaser can lag i/p phasor by an angle betn 0° & -90°.

Lead ckt :-

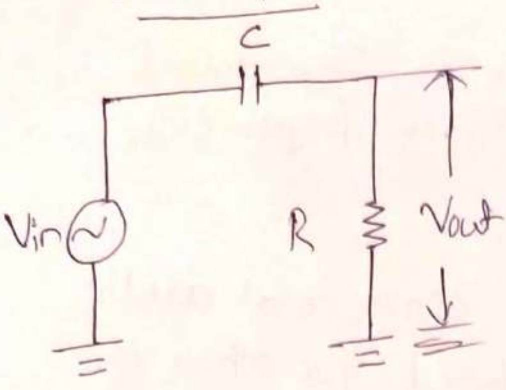


fig ⓐ coupling ckt

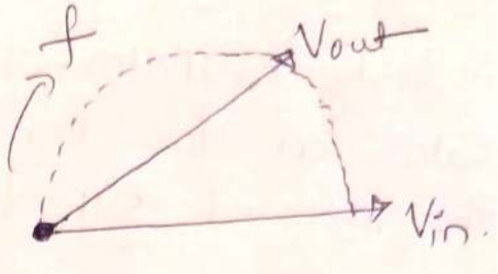


fig ⓑ phasor diagram.

let consider coupling ckt, the voltage gain of above ckt is given by

$$\frac{V_{out}}{V_{in}} = \frac{R}{\sqrt{R^2 + X_c^2}}.$$

& $\phi = \arc\tan \frac{X_c}{R}.$

Here phase angle is +ve hence o/p voltage leads input voltage

→ The half circle shows the possible positions of o/p phasor voltage. This implies that o/p phasor can lead the input phasor by an angle betn 0° & +90°.

⊛ Lead-lag Circuit :-

when wein-bridge osillator uses a resonant feedback ckt called as lead-lag-ckt.

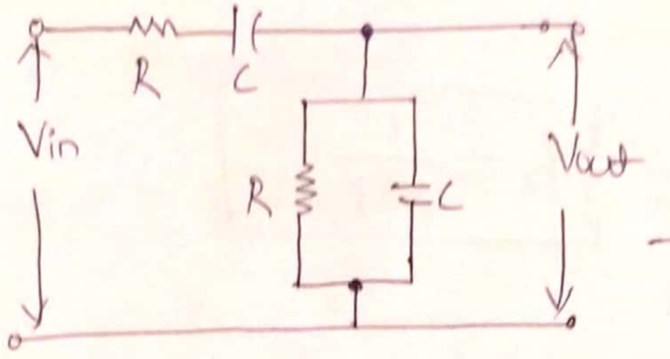


Fig. lead lag ckt.

→ at low freq the series capacitor acts as open to i/p signal, & there is no output signal.

→ At high freq, the shunt capacitor looks shorted, and there is a no output.

→ In between these extremes, the output voltage reaches a maximum value.

Resonant freq :- The frequency where the output is maximum. At this freq, the feedback fraction B reaches a maximum value of 1/3.

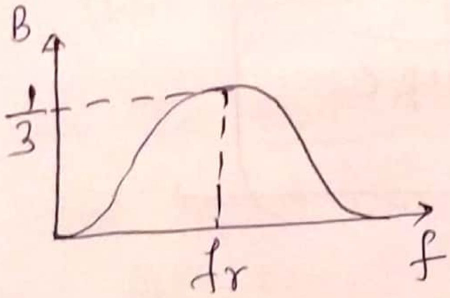


fig ⓐ Voltage gain

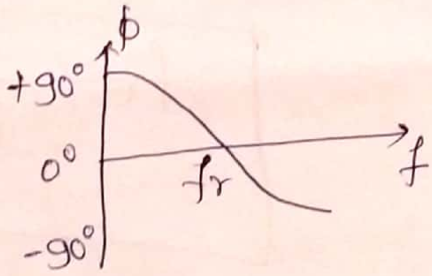
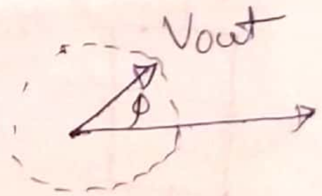


fig ⓑ. phase response.



ⓒ phasor diagram

→ let consider fig it indicates that phase angle of O/P voltage Vs input voltage.

→ At low freq the phase angle is positive

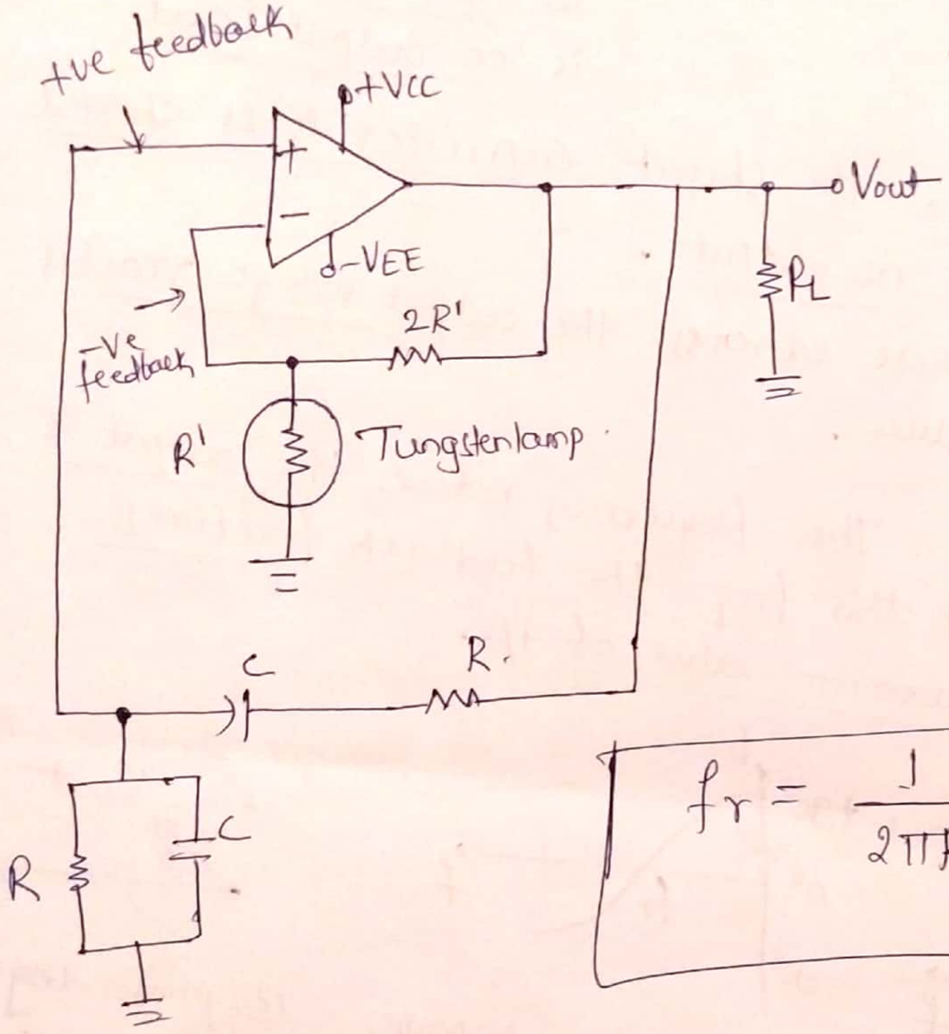
→ At high freq " " " Negative.

→ At resonant freq the phase shift is 0°.

at resonant freq $\underline{X_c = R}$

$$\therefore \frac{1}{2\pi f_r C} = R$$

$$\boxed{\therefore R = \frac{1}{2\pi f C}} \quad \underline{OR} \quad \boxed{f_r = \frac{1}{2\pi R C}}$$



$$\boxed{f_r = \frac{1}{2\pi R C}}$$

EP-M3-16

RC oscillators :-

① Twin-T- oscillator.

② Phase- shift oscillators.

1. Twin-T- ~~oscillator~~ Filter :-

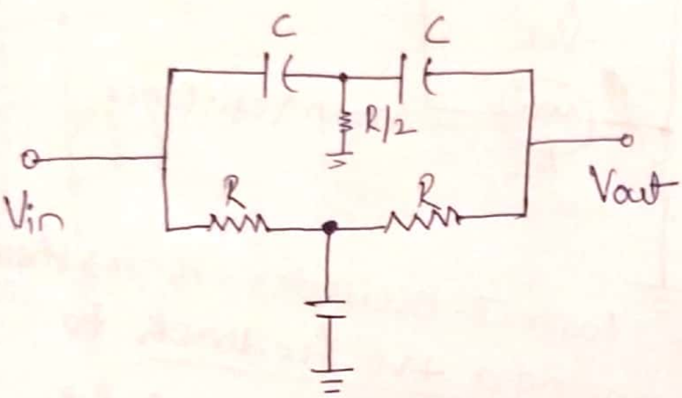


Fig. Twin-T- filter

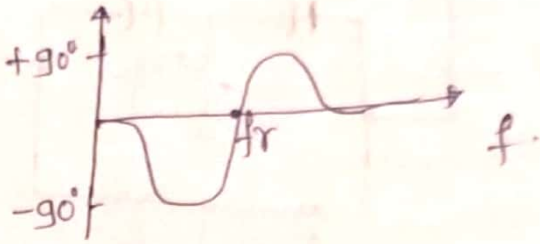


fig ⓑ Phase response.

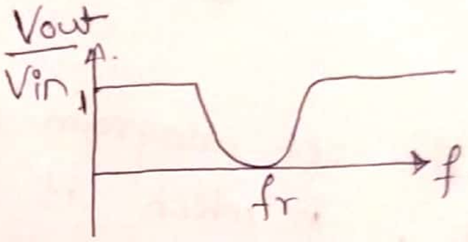


fig. ⓒ Frequency Response.

→ A twin-T- filter is acts like a lead lag circuit with a changing phase angle.

→ Let consider resonant frequency 'fr' where phase shift equals to 0°. as shown in fig. ⓑ.

→ In twin-T- filter the voltage gain is equal to 1 at low & high frequencies.

beth low & high freq, resonant frequency available at which voltage gain drops to 0. fig. ⓒ

$$\boxed{f_r = \frac{1}{2\pi RC}}$$

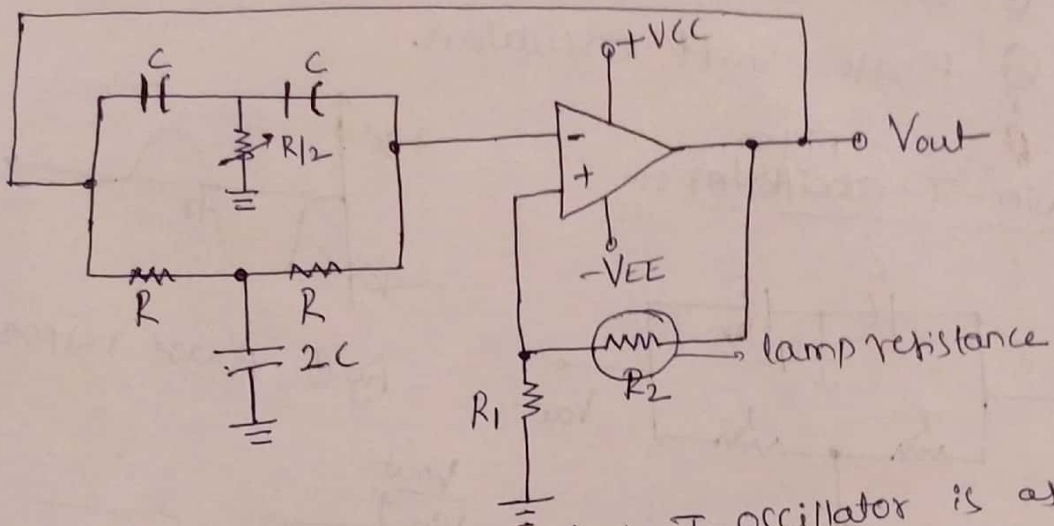
Key points :-

$\phi = 0$ at resonant freq.

$A_v = 1$ at low & high freq & 0 at f_r.

Twin-T Oscillator :-

Key point



→ The ckt diagram for twin-T-oscillator is as shown in fig. in which it is having a +ve feedback to the non inverting input through Voltage divider R_1 & R_2

→ Using a -ve feedback through twin T filter.

when power is turned ON the lamp resistance 'R_2' is low. & +ve feed back is more or maximum. But as oscillations buildup lamp resistance increses where as +ve feedback decreses.

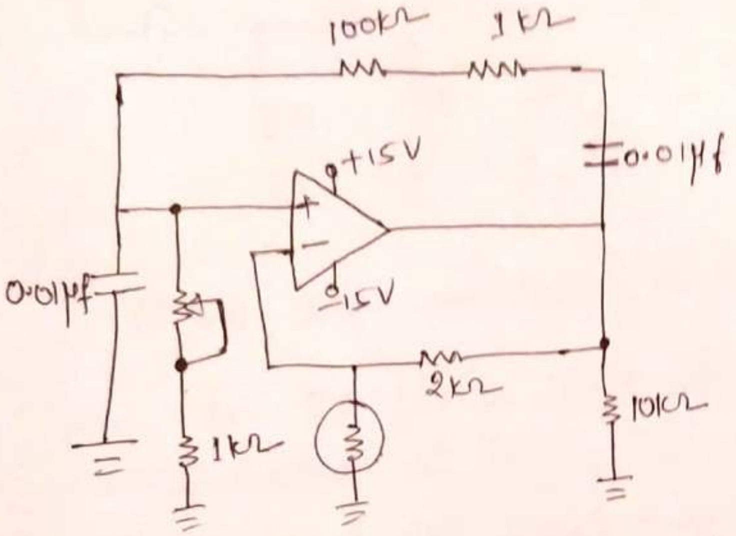
→ As feedback decreses, the oscillations level off & become constant.

→ In twin-T- filter resistance R/2 is adjusted it is necessary because the circuit oscillates at a frequency slightly different from ideal resonant frequency.

Key point :- +ve feed back at NI
& -ve feedback at Twin t filter.
→ when power ON - R_2 is low +ve feed backmore
but as oscillation increse ~~R2 is~~ +ve feed decreses & lamp Resistance increses.

EP4C-M3-15

⇒ Problem :-



For the shown ckt calculate minimum & maximum frequencies. The two variable resistors are ganged, which means that they change together & have the same value for any wiper position.

Soln :→ $R = 100k\Omega$ & $R = 1k\Omega$.

$$f = \frac{1}{2\pi RC}.$$

The minimum freq. of oscillation is

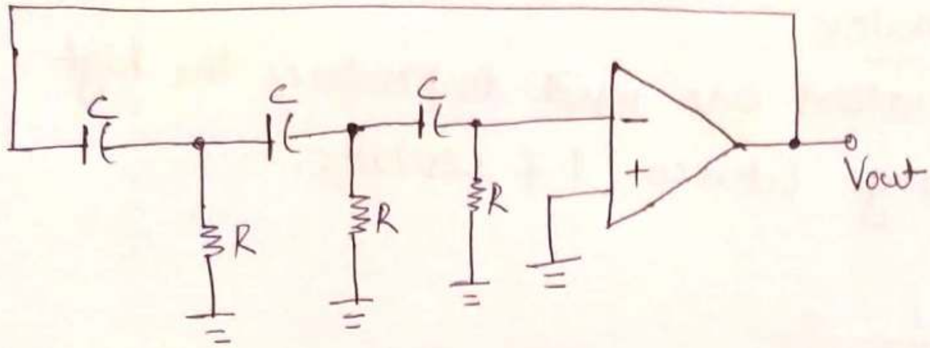
$$f_r = \frac{1}{2\pi RC} = \frac{1}{2\pi[101k\Omega][0.01\times10^{-6}]} = 158\,Hz.$$

The maximum freq of oscillation is

$$f_r = \frac{1}{2\pi RC} = \frac{1}{2\pi[1k\Omega](0.01\times10^{-6})} = 15.9\,kHz$$

② Phase Shift oscillators :-

EP-M3-17



phase shift oscillator with three lead ckt.

→ In RC phase shift oscillator there is a three combinations of R & C in feedback path.

→ a lead ckt producess a phase shift betn 0° to 90°. Hence in the above ckt each combination of R&C producess 60° of phase shift hence total phase shift around ckt is 180° & amplifier producess 180° of phase shift hence total phase shift = 360°.

ckt producess requied oscillation.

→ $|A_v \beta| > 1$

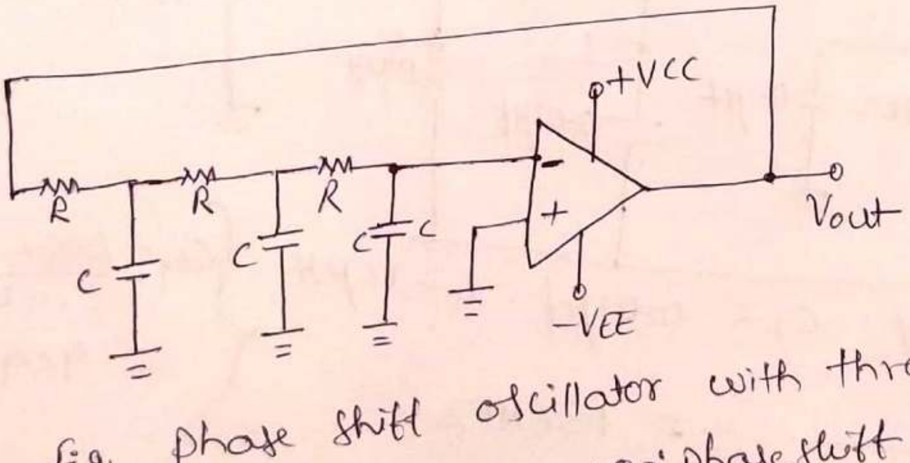


fig. phase shift oscillator with three lag ckt.

→ amp. producess → 180° phase shift

3 RC combination" → $-180°$ "

$0°$ phaseshift.

$|A_v \beta| > 1$, ckt producess oscillation.

The colpitts oscillator

LC oscillators are used to produce the high frequency range between 1 & 500 MHz.

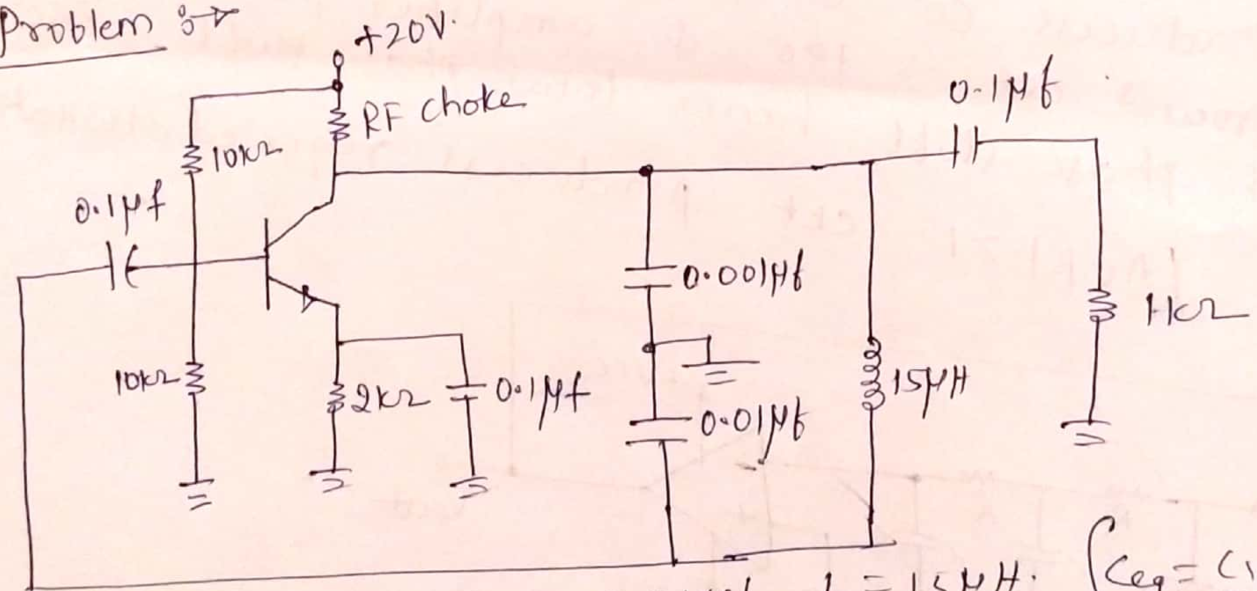
$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$C = \frac{C_1 C_2}{C_1 + C_2}$$

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

$$A_{v(min)} = \frac{C_2}{C_1}$$

⇒ Problem :-



Sol: $C_1 = 0.001\mu f$, $C_2 = 0.01\mu f$, $L = 15\mu H$. $\left\{ C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = 909pf \right)$

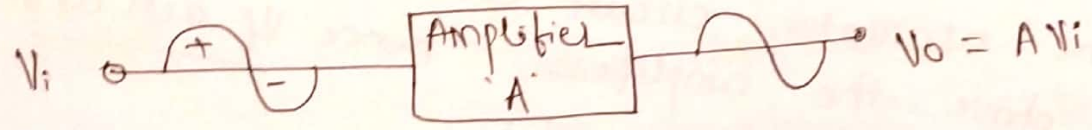
$$f_r = \frac{1}{2\pi\sqrt{(15\mu H)[909pf]}} = 1.36 MHz.$$

$$B = \frac{C_1}{C_2} = \frac{0.001 \times 10^{-6}}{0.01 \times 10^{-6}} = 0.1$$

$$A_{v(min)} = \frac{0.01 \times 10^{-6}}{0.001 \times 10^{-6}} = 10.$$

(4) <u>Barkhausen criterion</u> :- The condition for sustained oscillations is derived from German scientist Barkhausen hence it is called as <u>Barkhausen criterion.</u>

Let consider a inverting amplifier ckt with an open loop gain 'A', As the amplifier is inverting it producess a phase shift of 180° beth input & output



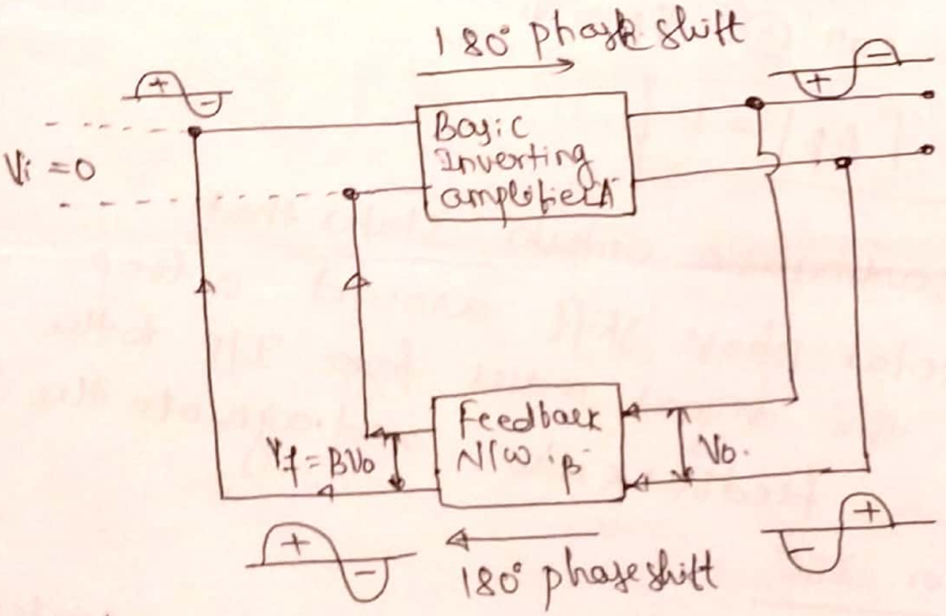


fig: Basic Block diagram of oscillator ckt

→ In the above fig. the feedback used is the +ve feed back. i.e the output voltage is in phase with input voltage.

→ As here we are using the inverting amplifier then it producess the phase shift of 180° and the feedback N/w introduce a phase shift o 180°. so that the phase shift around a loop is 360°

Let consider a input voltage V_i is applied at the input of amplifier

$$V_o = A V_i \quad \text{—— (1)}$$

The feedback voltage V_f is given by

$$V_f = \beta V_o \quad \text{—— (2)}$$

put eqn (1) in (2)

$$V_f = \beta A V_i \quad \text{—— (3)}$$

For the oscillator circuit we want that feedback should drive the amplifier. hence V_f acts as V_i

hence in eqn (3) $V_f = V_i$.

$$\boxed{\therefore |A\beta| = 1}$$

→ The Barkhausen criteria states that

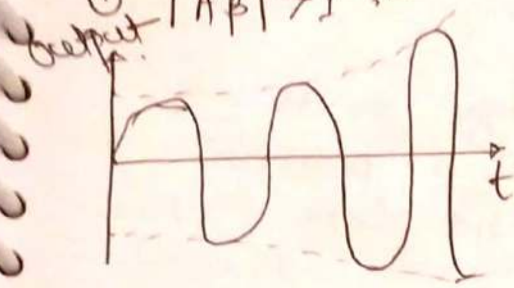
(1) The total phase shift around a loop. i.e as the signal moves from I/P to the amplifier, feedback N/w and again to the I/P is 0° or 360°.

(2) The magnitude of the product of open loop gain of amplifier (A) & the magnitude of the feedback factor β is unity $|A\beta| = 1$.

By satisfying these conditions the circuit works as an oscillator by producing the sustained oscillations of constant amplitude & frequency.

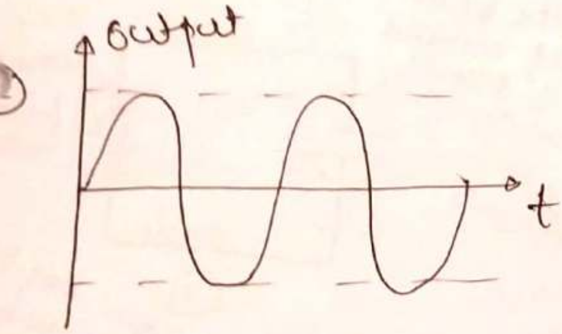
Different cases of $|A\beta|$:-

① $|A\beta| > 1$:-



when the total phase-shift around a loop is 0° or 360° and $|A\beta| > 1$ then ~~produces~~ output oscillates & the oscillations are of growing type. i.e the amplitude of oscillations are growing.

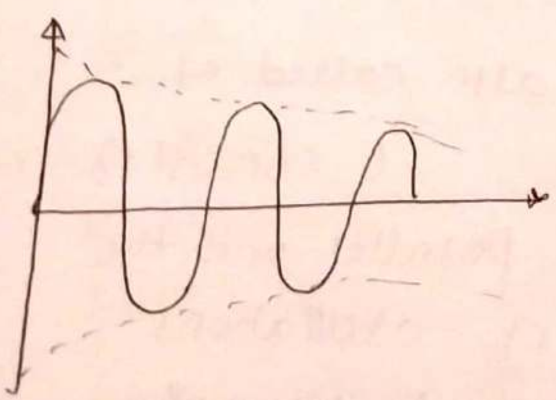
②



when $|A\beta| = 1$.

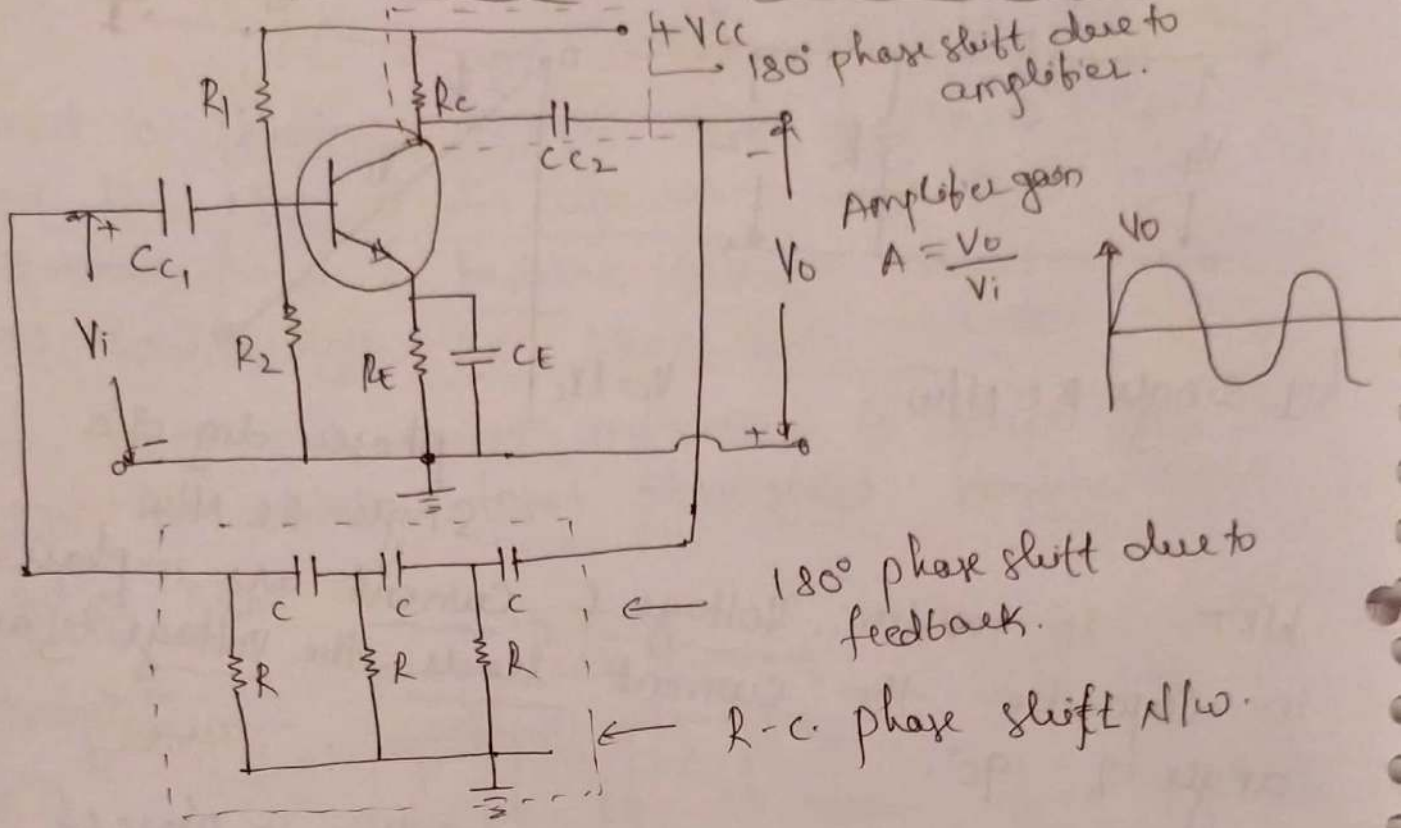
The barkhausen criterion states that when total phase shift around a loop is 0° or 360° and having a +ve feedback & $|A\beta| = 1$ then it produces a constant frequency and amplitude called as sustained oscillations.

③ $|A\beta| < 1$. :-



when the total phaseshift around loop is 0° or 360° but $|A\beta| < 1$ then the oscillations are decaying type i.e. the amplitude ~~of~~ decreases exponentially and oscillations finaly cease. so that the ckt works as amplifier without oscillations.

Transistorized RC phase shift oscillator ckt :-



→ In this ckt a transistor used as active element of amplifier stage.

→ Here this ckt consist of the common emitter (CE) ~~amplifier~~ transistor as amplifier ckt and feedback N/w consisting of capacitor and resistors.

CE :→ I/P is applied b/w the base & emitter and o/p is taken b/w emitter & collecter is called as CE ckt.

→ The resistor R_1, R_2, & R_E provides a Necessary bias to the ckt, and capacitor C_{C1} & C_{C2} are coupling capaciter.

→ The feedback N/w consist of the three RC sections, each R-C section producess a phase-shift of 60° to get a total phase shift of 180° we are using the three RC N/w's

→ In the RC phase shift oscillator the CE producess a phase shift of 180° and the RC N/w producess a phase shift of 180° hence the total phase shift around the loop is 360° this satisfies the required condition for +ve feedback.

→ when feedback is adjusted such that $|A\beta| = 1$ the ckt works as oscillator.

The frequency of RC phase shift oscillator is given by

$$\boxed{f = \frac{1}{2\pi RC\sqrt{6+4k}}}$$

where $k = \frac{R_C}{R}$.

For the most of practical ckt the freq. of ckt can be calculated as

$$\boxed{f = \frac{1}{2\pi\sqrt{6}RC}}$$

The current gain 'h_{fe}' of the transistor must satisfy the condition

$$\boxed{h_{fe} > 4k + 23 + \frac{29}{k}}$$

Advantages :-

→ The ckt is simple to design.

→ ckt producess a sinusoidal o/p waveform.

→ It is a fixed freq. oscillator

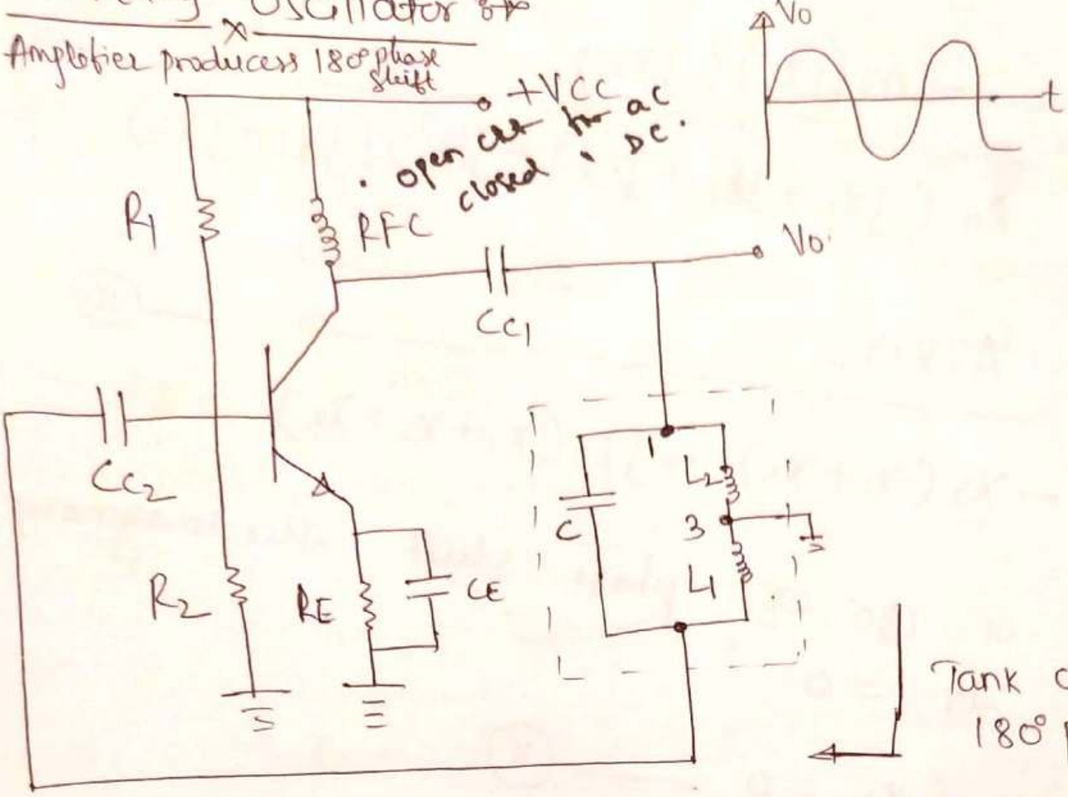
Disadvantages :-

→ It is a fixed freq. oscillator.

→ Frequency stability is poor.

Hartley oscillator

Amplifier producess 180° phase shift



Tank ckt adds 180° phase shift.

→ Hartley oscillator ckt is a oscillator ckt which uses the two inductors and one capacitor in its tank ckt

→ The inductors L_1 & L_2 are connected in series and connected in parallel with 'C'. to complete a tank ckt.

→ The resistor R_1, R_2 & RE provides a necessary bias to the circuit. and capacitor C_{C_1} & C_{C_2} are coupling capacitors.

→ Here the feedback ckt consist of the tank circuit madeup of two inductor L_1 & L_2 and capacitor

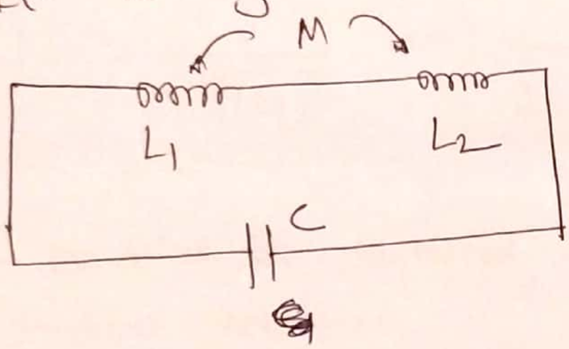
→ It consist of Radio frequency choke as a large inductor the main function of RFC is that it acts as open ckt for AC supply & closed ckt for D.C. supply.

→ The main function of the RFC is to achive the isolation betn AC & DC condition.

→ Here CE amplifier ckt producess a phase shift of 180° and tank ckt ie. feedback ckt producess a phase shift of 180° hence the total phase shift around ckt is 360° or 0°.

→ The feedback is adjusted in such a way that $|A\beta| = 1$, then ckt works as oscillator ckt

Derivation for freq. of oscillation in Hartley oscillator ckt. is given by



In feed back ckt sum of all the 3 reactances must be equal to zero.

$$jX_{L_1} + jX_{L_2} + \frac{1}{jX_C} = 0$$

$$jX_{L_1} + jX_{L_2} - jX_C = 0$$

$$\cancel{j}[X_{L_1} + X_{L_2}] = \cancel{j}X_C$$

$$\omega L_1 + \omega L_2 = \frac{1}{\omega C}$$

$$\omega[L_1 + L_2] = \frac{1}{\omega C}$$

$$\omega^2 = \frac{1}{(L_1 + L_2)C}$$

$$\omega = \frac{1}{\sqrt{L_{eq} C}}$$

where $L_{eq} = L_1 + L_2$

$$2\pi f = \frac{1}{\sqrt{L_{eq} C}} \Rightarrow \boxed{f = \frac{1}{2\pi\sqrt{L_{eq} C}}}$$

The mutual Inductance is considered ~~calculated~~ while determining the equivalent Inductance

$$\boxed{L_{eq} = L_1 + L_2 + 2M.}$$

→ The condition for sustained oscillation is given by

$$\boxed{h_{fe} \geq \frac{L_1 + M}{L_2 + M}.}$$

Neglecting mutual Inductance then

$$\boxed{h_{fe} \geq \frac{L_1}{L_2}}$$

Formulae :-

① $f = \frac{1}{2\pi \sqrt{L_{eq} C}}$

$L_{eq} = L_1 + L_2 + 2M$

when $M = 0$.

$$\boxed{L_{eq} = L_1 + L_2}$$

② condition for sustained oscillation is given by

$$\boxed{h_{fe} \geq \frac{L_1}{L_2}}$$

1. The following ckt parameter values are given for the hartley oscillator $L_1 = 750\mu H$, $L_2 = 750\mu H$, $M = 150\mu H$, $C_1 = 150pF$, $h_{fe} = 50$

(a) Calculate the freq of oscillations.

(b) Check to make sure that the condition for oscillation is satisfied.

Sol^n : WKT $f = \dfrac{1}{2\pi\sqrt{L_{eq}C}}$

$L_{eq} = L_1 + L_2 + 2M$

$L_{eq} = 750\mu H + 750\mu H + 2(150\times10^{-6})$

$L_{eq} = 1800\mu H$

$$f = \frac{1}{2\pi\sqrt{L_{eq}C}} = \frac{1}{2\pi\sqrt{(1800\mu H)\times150\times10^{-9}}} = 306.25 KHz$$

(b) condition for sustained oscillation by considering the mutual inductance.

$$h_{fe} \geq \frac{L_1+M}{L_2+M}$$

$$h_{fe} \geq \frac{750\times10^{-6} + \cancel{150\times10^{-6}}}{\cancel{750\times10^{-6} + 150\times10^{-6}}}$$

$h_{fe} \geq 1$.

WKT $h_{fe} = 50$.

Here $h_{fe}\ (50) > 1$. hence the ckt oscillates

② In a transistor hartley oscillator, $L_1 = 10\mu H$, $L_2 = 10\mu H$ find the value of 'C' required for an oscillating freq. of 150KHZ.

Soln :- $L_1 = 10\mu H$, $L_2 = 10\mu H$ $f = 150KHZ$, $C = ?$

$$f = \frac{1}{2\pi\sqrt{L_{eq}C}}$$

$L_{eq} = L_1 + L_2 + 2M$. { here M is not given hence M=0 }

$L_{eq} = 20\mu H$

$$\therefore f = \frac{1}{2\pi\sqrt{L_{eq}C}}$$

$$f^2 = \frac{1}{4\pi^2(\cancel{\sqrt{}}L_{eq}C)^{\cancel{2}}}$$

$$f^2 = \frac{1}{4\pi^2 L_{eq} C} = \frac{1}{4\pi^2 \times 20\times10^{-6}\times f^2}$$

$$C = \frac{1}{4\pi^2\times20\times10^{-6}\times(150\times10^3)^2}$$

$$\boxed{C = 56.28nf}$$

---

① In a ckt. two inductances $L_1 = 30\mu H$, $L_2 = 21\mu H$ & Mutual Inductance is $150\mu H$. and frequency of the ckt is $f = 200KHZ$ find value of C.

Colpits Oscillator :-

→ Amplifier producess a 180° phase shift

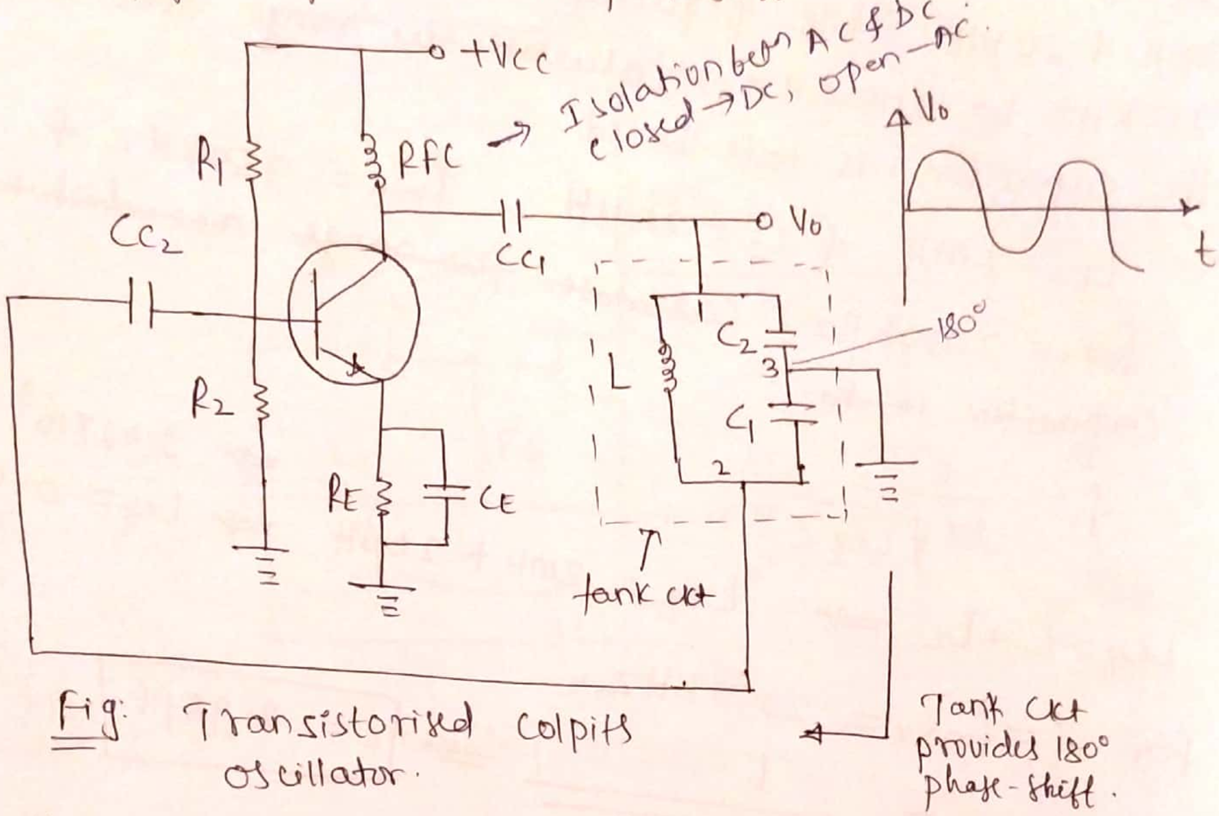


Fig: Transistorised colpits oscillator.

"The oscillator circuit, in which tank circuit consist of a two capacitors C_1 & C_2 are in series, and also it consist of Inductor 'L' which is in parallel with two capacitors C_1 & C_2".

→ The resistor "R_1, R_2 & R_E" provides a Necessary bias to the circuit and "R_E" performs the dual functions i.e it acts as emitter resistance & as well as the colpits oscillator component.

→ Here the capacitor CC_1 & CC_2 are coupling capacitors

→ The "Radio frequency choke" is used to achieve the isolation betn AC & dc conditions.

ⓐ The RFC allows the dc current to pass through it easily i.e acts as a short circuit for the d.c current.

ⓑ Acts as open ckt for the A.C. current.

→ when the switched is 'ON' then the current flows in the tank circuit and produces a voltage across C_1 & C_2. i.e Tank circuit provides a 180° of phase shift & CE amplifier provides a phase shift of 180° hence the total phase shift around the ckt is 360°.

→ and when the feedback is adjusted such that $|A\beta|=1$ then the ckt works as oscillators.

The o/p of the ckt is coupled to the load through a transformer

The transformer coupling has following advantages

(a) It provides an electrical oscillations betn the oscillator o/p & the load.

(b) It provides an impedence matching betn oscillator o/p & load

The frequency of oscillation is given by

$$\boxed{f = \frac{1}{2\pi\sqrt{LC_{eq}}}} \quad \text{where } C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

The condition for sustained oscillation is given by

$$\boxed{h_{fe} \geq \frac{C_2}{C_1}}$$

→ This oscillator ckt is determined by the scientist colpits hence it is called as Colpits oscillator.

→ This ckt uses the capacitive feedback and it produces a phase shift of 180°

→ This ckt produces a pure sinewave oscillation.

→ In this ckt when the upper plate of capacitor 'C_1' charges +ly then the lower plate of capacitor 'C_2' becomes -ve, hence the base of transistor recives a phase shift of 180°.

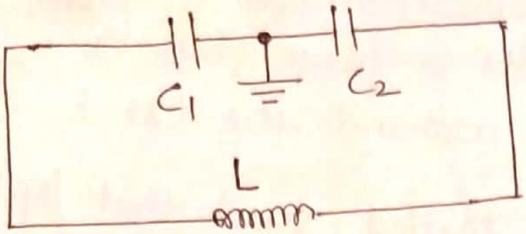
Formulas:-

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

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

$$h_{fe} > C_2/C_1$$

Derivation for colpits oscillator



The sum of all three reactances must be equal to zero.

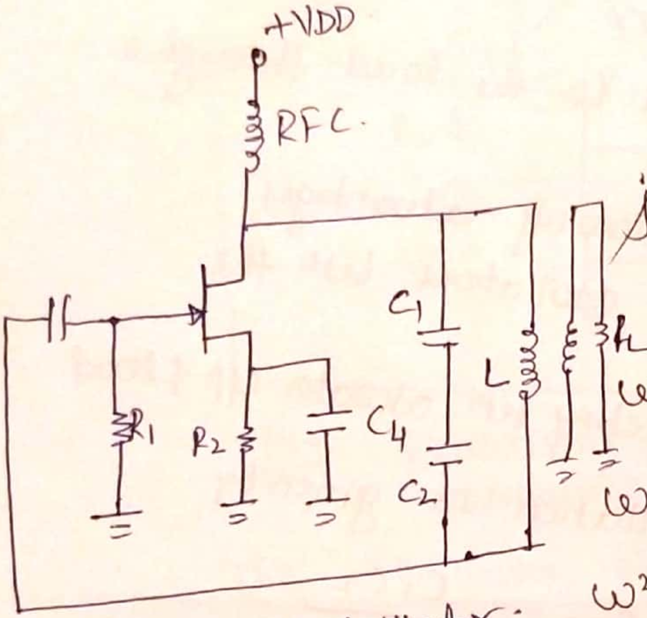
$$\frac{1}{jX_{C1}} + \frac{1}{jX_{C2}} + jX_L = 0.$$

$$-jX_{C1} - jX_{C2} + jX_L = 0$$

$$jX_L = jX_{C1} + jX_{C2}$$

$$\cancel{j} X_L = \cancel{j}[X_{C1} + X_{C2}]$$

$$X_L = X_{C1} + X_{C2}$$



FET colpits oscillator.

$$\omega L = \frac{1}{\omega C_1} + \frac{1}{\omega C_2}$$

$$\omega L = \frac{1}{\omega}\left[\frac{1}{C_1} + \frac{1}{C_2}\right]$$

$$\omega^2 = \frac{1}{L}\left[\frac{1}{C_1} + \frac{1}{C_2}\right]$$

$$\omega^2 = \frac{1}{L}\left[\frac{C_1 + C_2}{C_1 C_2}\right] \Rightarrow \omega^2 = \frac{C_1 + C_2}{L[C_1 C_2]}$$

$$\omega^2 = \frac{1}{L\left[\frac{C_1 C_2}{C_1 + C_2}\right]}$$

$$(2\pi f)^2 = \frac{1}{L\left[\frac{C_1 C_2}{C_1 + C_2}\right]}$$

$$(2\pi f)^2 = \frac{1}{L C_{eq}} \quad \left\{ \because C_{eq} = \frac{C_1 C_2}{C_1 + C_2} \right\}$$

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

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

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① The following data are available for the Colpits oscillator $C_1 = 1nf$, $C_2 = 99nf$, $L = 1.5mH$

$L_{RFC} = 0.5mH$, $C_c = 10\mu f$, $h_{fe} = 110$

① calculate the freq. of oscillation.

② Check to make sure that the condition for oscillation is satisfied.

Soln $C_1 = 1nf$, $C_2 = 99nf$, $L = 1.5mH$, & $h_{fe} = 110$.

WKT $C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{(1 \times 10^{-9}) \times (99 \times 10^{-9})}{(1 \times 10^{-9}) + 99 \times 10^{-9}} = 0.99nf$

$f = \frac{1}{2\pi\sqrt{L C_{eq}}} = \frac{1}{2\pi\sqrt{(1.5 \times 10^{-3}) \times (0.99 \times 10^{-9})}}$

$\boxed{f = 130.6 KHz.}$

⑥ condition for sustained oscillation is

$h_{fe} \geq \frac{C_2}{C_1}$

$110 \geq \frac{99 nf}{1 nf}$

$\boxed{110 \geq 99.}$

∴ The ckt producesa required oscillations.

② In a transistor colpits oscillator $C_1 = 1nf$ $C_2 = 100nf$ find the value of 'L' for a freq. of 100KHz.

Soln: $C_1 = 1nf$, $C_2 = 100nf$. $f = 100KHz$ $L = ?$

$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{(1 \times 10^{-9}) \times (100 \times 10^{-9})}{(1 \times 10^{-9}) + (100 \times 10^{-9})} = 0.99nf$

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

$f^2 = \frac{1}{4\pi^2(\sqrt{C_{eq} L})^2} \Rightarrow L = \frac{1}{4\pi^2 f^2 C_{eq}}$

$= \frac{1}{4\pi^2 \times (100KHz)^2 \times (0.99 \times 10^{-9})}$

$L = 2.55mH$

③ In a colpits oscillator $C_1 = C_2 = C$ & $L = 100\mu H$. The frequency of oscillation is 500KHz, Determine the value of 'C'.

Sol^n

$L = 100\mu H$, $C_1 = C_2 = C$, $f = 500kHz$

WKT $f = \dfrac{1}{2\pi\sqrt{L \cdot C_{eq}}}$

$$f^2 = \frac{1}{4\pi^2 (\cancel{\sqrt{L \cdot C_{eq}}})^{\cancel{2}}} \Rightarrow C_{eq} = \frac{1}{4\pi^2 f^2 L}$$

$$C_{eq} = \frac{1}{4\pi^2 \times (500\times10^3)^2 \times 100\times10^{-6}} \Rightarrow 1$$

$$\boxed{C_{eq} = 1.0132\times10^{-9} F}$$

but $C_{eq} = \dfrac{C_1 C_2}{C_1 + C_2}$

Given: $C_1 = C_2 = C$

$$\therefore \quad C_{eq} = \frac{(C)\times(C)}{C + C} \Rightarrow \frac{C^{\cancel{2}}}{2\cancel{C}}$$

$$C_{eq} = C/2$$

$$C = 2C_{eq} \Rightarrow C = 2\times1.0132\times10^{-9}.$$

$$\boxed{C = 2.026nf}$$

④ Find the frequency of oscillations of transistorised colpitts oscillator having tank ckt parameters as $C_1 = 150pf$, $C_2 = 1.5nf$, & $L = 150\mu H$

Sol^n

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} \Rightarrow 136.363\times10^{-12} f.$$

$$f = \frac{1}{2\pi\sqrt{L C_{eq}}} \Rightarrow f = \frac{1}{2\pi\sqrt{(150\times10^{-6})\times(136.363\times10^{-12})}}$$

$$f = 1.927MHz.$$

Crystal oscillator :-

"The ckt in which the tank ckt is replaced by using crystal for the purpose of frequency stability". It employs the piezo-electric effect of a crystal.

Piezo electric effect :- The crystals of certain materials like quartz, rochell salt etc are having a property of generating the alternating voltage betn pair of opposite faces when an alternating pressure is applied on the other pair of faces perpendicular to the first pair

→ "i.e when an voltage is applied across the one face then another face starts to vibrate"

The oscillatory frequency of crystal depends on the thickness of crystal.

$$\boxed{f \propto \frac{1}{\text{thickness of crystal}}}$$

→ The Quartz crystals are most commonly used in the crystal oscillators because of it is a tough and stable material and it is inexpensive and easily available in Nature.

→ Crystal oscillators generates a frequency in the range of 50kHz to 50MHz.

Construction details :-

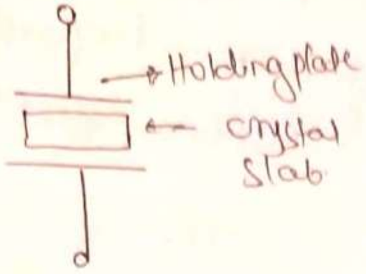
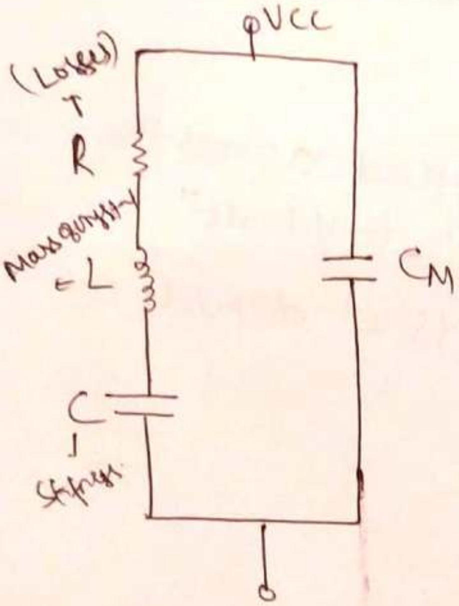


fig. Symbolic representation of crystal.

The Natural shape of the Quartz crystal is the hexagonal prism but for practical use it is cut into the rectangular slab.

→ The rectangular slab is held betn two metalic plates called as holding plates.

A.C. equivalent ckt :-



When the crystal is Not Vibrating, it is equivalent to capacitance due to mechanical mounting of crystal.

→ Here the two metalic plates are seperated by dielectric material i.e crystal slab is called as mounting capacitance "C_M"

→ when the crystal is Vibrating then the internal fractional losses are denoted by 'R'

→ the mass of the crystal is represented by inductor 'L'.

→ In the vibrating condition it is having some stiffness it is represented by 'C'

The RLC forms a resonating ckt

$$f_r = \frac{1}{2\pi\sqrt{LC}}\sqrt{\frac{Q^2}{1+Q^2}}$$

where 'Q' is Quality factor of crystal.

$$Q = \frac{\omega L}{R}$$

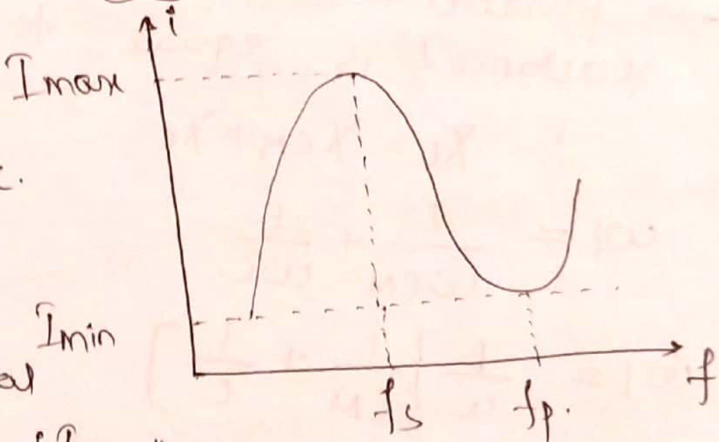
Q factor of crystal is very High i.e from 20,000 to 10^6 $\therefore \sqrt{\frac{Q^2}{1+Q^2}} =$ unity

$$\therefore \boxed{f_r = \frac{1}{2\pi\sqrt{LC}}}$$

The crystal freq. is ~~~~ inversely propotional to the thickness of crystal.

$$\boxed{f \propto \frac{1}{T}}$$

Frequency Response of crystal series Resonance :-



(i) Series Resonance :-

When the frequency of A.C. source (i.e f) is equal to the frequency "fs" then the current through the crystal ~~~~ becomes maximum 'Imax"

this condition is called as "Series Resonance" & "fs" is called as the series resonant frequency.

The series resonance occurs when the reactance of 'L' is equal to the reactance of 'C' in series 'RLC' Branch i.e $X_L = X_C$

$$\omega L = \frac{1}{\omega C}$$

$$\omega^2 = \frac{1}{LC}$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$\therefore \boxed{f = \frac{1}{2\pi\sqrt{LC}}}$$

Note:- since the current is maximum, the impedence of the crystal is minimum.

Parallel Resonance :-

when the frequency of A.C. source [f] is equal to the frequency "$f_p > f_s$" then the current through the crystal becomes minimum "I_{min}" this condition is called parallel resonance & "f_p" is called as parallel resonant frequency.

→ Parallel resonance occurs when the Inductive reactance 'L' is equal to the capacitive ~~[illegible]~~ reactance

$$\therefore X_L = X_{CM} + X_C$$

$$\omega L = \frac{1}{\omega C_M} + \frac{1}{\omega C}$$

$$\omega L = \frac{1}{\omega}\left[\frac{1}{C_M} + \frac{1}{C}\right]$$

$$\omega^2 = \frac{1}{L}\left[\frac{C + C_M}{C_M C}\right]$$

$$\omega^2 = \frac{1}{L\left[\frac{C_M C}{C + C_M}\right]}$$

$$\omega^2 = \frac{1}{LC_p} \quad \left\{C_p = \frac{C_M C}{C + C_M}\right\}$$

$$2\pi f = \frac{1}{\sqrt{LC_p}}$$

$$f = \frac{1}{2\pi\sqrt{LC_p}}$$

$$\boxed{\therefore f = f_p = \frac{1}{2\pi\sqrt{LC_p}}}$$

$\therefore$ when the current is minimum, the impedence of crystal is maximum.

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A crystal has the following parameters $L = 3H$, $C = 0.05pf$, $R = 2K\Omega$, $C_M = 10pF$ what are the series & parallel resonant freq. of crystal

Ans :- $f_s = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{3 \times 0.05 \times 10^{-12}}} = 410.931 KHZ$

$$f_p = \frac{1}{2\pi\sqrt{LC_p}}$$

$$C_p = \frac{C_m C}{C + C_M} = \frac{10 \times 10^{-12} \times 0.05 \times 10^{-12}}{10 \times 10^{-12} + 0.05 \times 10^{-12}} = \frac{5 \times 10^{-25}}{1.005 \times 10^{-11}}$$

$$C_p = 4.975 \times 10^{-14}$$

$$\boxed{C_p = 0.0497 \times 10^{-12}}$$

$$f_p = \frac{1}{2\pi\sqrt{3 \times 0.0497 \times 10^{-12}}} \Rightarrow f_p = \frac{1}{2\pi \times 3.863 \times 10^{-7}}$$

$$\boxed{f_p = 411.962 KHZ}$$

A crystal oscillator ckt $L = 0.4H$, $C = 0.085pf$, $C_M = 1pF$ with $R = 5K\Omega$ find.

ⓐ series & parallel resonant freq.

ⓑ By what the % does the parallel resonant frequency exceeds the series resonant freq ?

ⓒ find Q factor of ckt

The 555 Timer

The NE555, LM555 & CA555 are widely used IC timer. It is operated in two modes Monostable or Astable

→ In monostable it can produce time delay from microseconds to hours.

→ In astable mode it can produce rectangular waves with a variable duty cycle.

Monostable operation :-

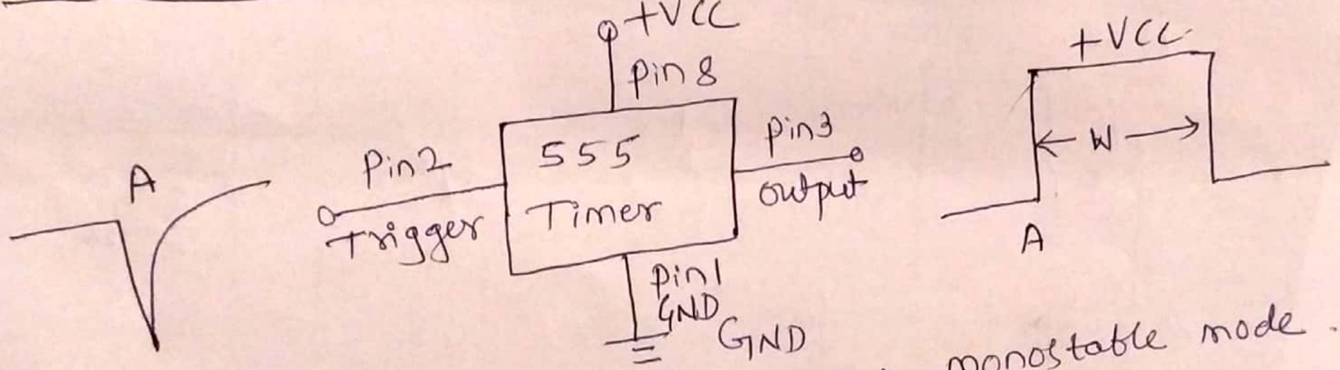

Fig. The 555 timer used in monostable mode.

→ Initialy 555 timer has low output voltage at which it can remain indefinitely.

→ When 555 timer receives a trigger at point A' in time, the output voltage switches from low to high.

→ The output remains high for some periode & then returns to low state after time delay of W.

→ output is in low state until it gets another trigger

Module 1

Assignment Questions.

1. With a neat ckt diagram explain summing ckt & Averager circuit.
2. With a ckt diagram & Necessary equations explain Bianary weighted D/A converter.
3. With a neat diagram explain inverting comparator ckt. & compatator with non zero refference.
4. Explain INV Schimmit trigger & NINV Schimmit trigger.
5. With a Neat diagram explain Barkhusen criteria for theory of sinusoidal oscillation.
6. Explain weinbridge oscillator with lead & lag N/W
7. With a neat ckt diagram explain Twin-T - oscillator & RC phase shift oscillator.
8. With a Neat ckt diagram & Necessary equations explain Hartely & Colpits oscillator. & crystal oscillator.
9. With a functional diagram explain 555 timer used a monostable & Astable multivibrator.