≈ 2(6)

(6) (a) Stagger tuned amplifier

- In simple, the amplifier that uses staggered tuning to give the wide B.W.
- To overcome the problem, two single tuned cascaded amplifiers having certain B.W. are taken and their resonant frequencies are so adjusted that they are separated by an amount equal to the B.W. of each stage.
- The below fig. shows the relation of amplification characteristics of individual stages in a staggered pair to the overall amplification of the two stages:

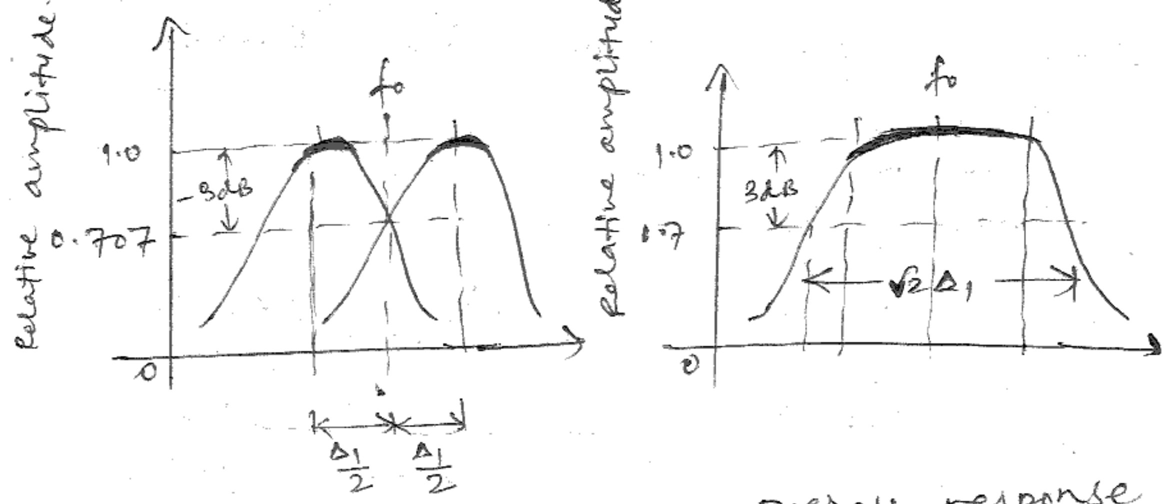


Fig 1. a) Response of individual stages

overall response of staggered pair.

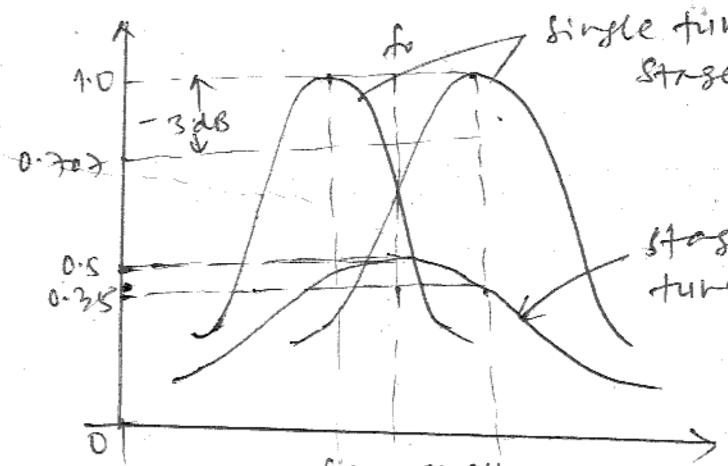


fig. 2. Response of individually tuned & staggered tuned pair

- While comparing both the figures 1 & fig. 2, it can be seen that staggering reduces the total amplification of the centre freq. to 0.5 of the peak amplification of the individual stage.

- At the centre frequency, each stage has an amplification i.e. 0.707 of the peak amplification of the individual stage.

- Thus, the equivalent voltage amplification per stage of the staggered pair is 0.707 times as great as when the same two stages are used without staggering.

- However, the half power (3dB) B.W. of the staggered pair is $\sqrt{2}$ times as great as the half power B.W. of an individual single tuned stage.

- Hence the eqn gain B.W. of a stagger tuned pair is $0.707\sqrt{2} = 1.00$ times that of the individual single tuned stages.

Option
Analysis

The gain of single tuned amplifier is,

$$\frac{A_v}{A_v(\text{at resonance})} = \frac{1}{1+2jQ_{eff}\delta}$$

$$= \frac{1}{1+jX} \quad \text{where } X = 2Q_{eff}\delta$$

∴ There are two single tuned cascaded amplifiers in stagger tuned amplifiers, with diffⁿ resonant frequencies.

One stage is tuned to freq., $f_{r1} = f_r + \delta$
other " " " " ", $f_{r2} = f_r - \delta$

A/c to these tuned freq, the selectivity funcⁿ can be given as,

$$\frac{A_v}{A_v\,(\text{at resonance})_1} = \frac{1}{1+j(X+1)} \quad \&$$

$$\frac{A_v}{A_v\,(\text{at resonance})_2} = \frac{1}{1+j(X-1)}$$

overall gain,

$$\frac{A_v}{A_v\,(\text{at resonance})\,\text{cascaded}} = \frac{A_v}{A_v\,(\text{at resonance})_1} \times \frac{A_v}{A_v\,(\text{at resonance})_2}$$

$$= \frac{1}{1+j(x+1)} \times \frac{1}{1+j(x-1)}$$

$$= \frac{1}{2+2jx-x^2} = \frac{1}{(2-x^2)+(2jx)}$$

$$\therefore \left|\frac{A_v}{A_v\,(\text{at resonance})}\right|_{\text{cascaded}} = \frac{1}{\sqrt{(2-x^2)+(2x)^2}}$$

$$= \frac{1}{\sqrt{4+x^4}}$$

$$= \frac{1}{\sqrt{4+(2Q_{eff}\,\delta)^4}} = \frac{1}{\sqrt{4+16\,Q_{eff}^4\,\delta^4}}$$

$$= \boxed{\frac{1}{2\sqrt{1+4Q_{eff}^4\,\delta^4}}}$$

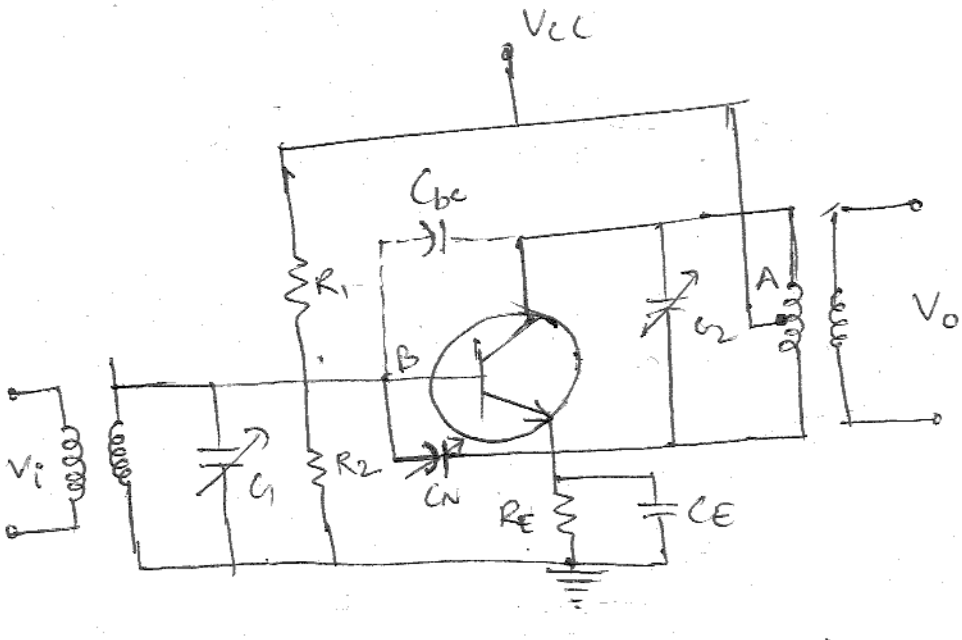
Advantages:
- to have a better flat, wideband characteristics, sharp, rejective, narrowband characteristics of synchronously tuned circuits.

≈ 2(a)

(b) Hazeltine neutralization Ckt :

- L.A. Hazeltine introduced a ckt. in which, the troublesome effect of the collector to base capacitance of the transistor can be neutralized by introducing a signal which cancels the signal coupled through the collector to base capacitance.

- The neutralization can be achieved by deliberately feeding back a portion of the o/p signal to the i/p in such a way that it has the same amplitude as the unwanted f/b but the opposite phase.



Tuned RF amplifier with Hazeltine neutralization.

- In this circuit, a small value of variable capacitance C_N is connected from the bottom of coil, point B, to the Base.

- Therefore, the internal capacitance C_{bc}, shown dotted, feeds a signal from the top end of the coil, point A, to the transistor base and the C_N feeds a signal of equal magnitude but opposite polarity from the bottom of coil, point B, to the base.

- The neutralizing capacitor, C_N, can be adjusted correctly to completely nullify the signal fed through the C_{bc}.

8) Effect of cascading a single tuned and double tuned amplifiers on B.W.

- The overall gain is the product of the ~~states.~~ voltage gains of the individual stages where several identical stages of tuned amplifiers can be used in cascade.

- Consider n stages of single tuned direct coupled amplifiers connected in cascade.

We know the relative gain of a single tuned amplifier w.r. to the gain at resonant frequency f_r is given by

$$\left| \frac{A_v}{A_v (\text{at resonance})} \right| = \frac{1}{\sqrt{1 + (2\delta Q_{eff})^2}}$$

∴ The relative gain of n stage cascaded amplifier becomes

$$\left| \frac{A_v}{A_v (\text{at resonance})} \right|^n = \left| \frac{1}{\sqrt{1+(2\delta Q_{eff})^2}} \right|^n$$

$$= \frac{1}{\left[1+(2\delta Q_{eff})^2\right]^{n/2}} \quad \text{— (1)}$$

The 3dB frequencies for the n-stage cascaded amplifier can be found out by equating

$$\left| \frac{A_v}{A_v (\text{at resonance})} \right|^n = \frac{1}{\sqrt{2}} \quad \text{— (2)}$$

$$\therefore \frac{1}{\left[1+(2\delta Q_{eff})^2\right]^{n/2}} = \frac{1}{\sqrt{2}}$$

$$\left[1+(2\delta Q_{eff})^2\right]^{n/2} = 2^{1/2}$$

$$\left[1+(2\delta Q_{eff})^2\right]^n = 2$$

$$1+(2\delta Q_{eff})^2 = 2^{1/n} \quad \text{— (3)}$$

$$2\delta Q_{eff} = \pm\sqrt{2^{1/n}-1}$$

substituting, for δ, the fractional freq. variation,

$$\delta = \frac{\omega - \omega_r}{\omega_r} = \frac{f - f_r}{f_r}$$

$$2\left(\frac{f - f_r}{f_r}\right) Q_{eff} = \pm \sqrt{2^{1/n} - 1}$$

$$\therefore \quad f - f_r = \pm \frac{f_r}{2Q_{eff}} \sqrt{2^{1/n} - 1}$$

Let us assume f_1 and f_2 are the lower 3dB and upper 3dB freq, resp.

$$f_2 - f_r = \pm \frac{f_r}{2Q_{eff}} \sqrt{2^{1/n} - 1}$$

$$f_r - f_1 = + \frac{f_r}{2Q_{eff}} \sqrt{2^{1/n} - 1}$$

$\therefore$ The B.W. of n stage identical amp.

$$BW_n = f_2 - f_1$$

$$= (f_2 - f_r) + (f_r - f_1)$$

$$= \frac{f_r}{2Q_{eff}} \sqrt{2^{1/n} - 1}$$

$$\boxed{BW_n = BW_1 \sqrt{2^{1/n} - 1}}$$

Effect of cascading double tuned amplifier on B.W.

- When a no. of identical double tuned amplifier stages are connected in cascade, the overall B.W. of the system is thereby narrowed & the steepness of the sides of the response is increased.

The quantitative relation b/w the 3dB B.W of n identical double tuned critically coupled stages compared with the B.W Δ_2 of such systems can be shown to be 3dB B.W. for

n identical stages double tuned amplifiers $= \Delta_2 \times (2^{1/n}-1)^{1/4}$

where, A_2 → 3dB B.W of single stage double tuned amplifier.

(9) Various Neutralization techniques:

i) Hazeltine neutralization.
(ii) [Refer to 6(b)]

ii) Neutrodyne Neutralization

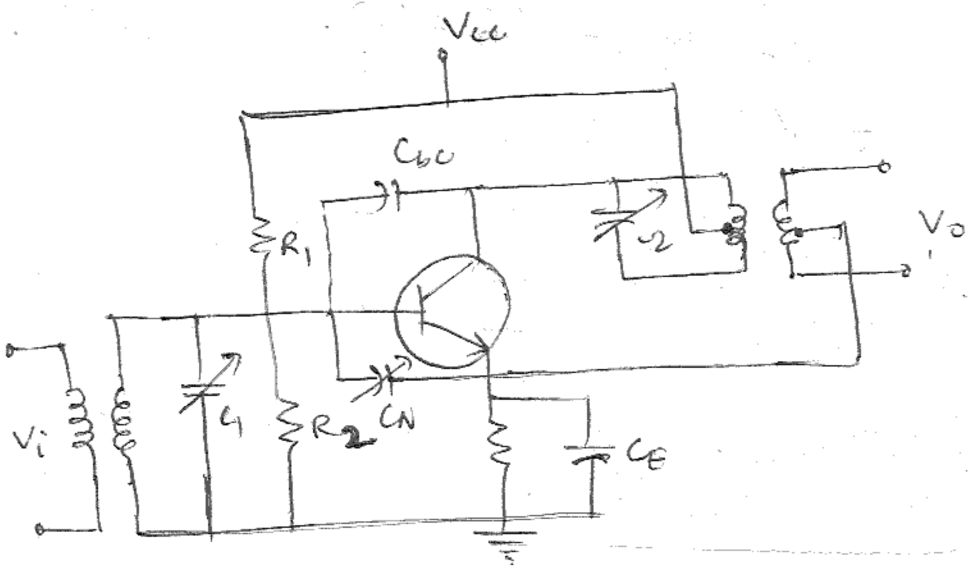


Fig. Tuned RF amplifier with Neutrodyne neutralization.

- In this ckt, the neutralization capacitor is connected from the lower end of the base coil of the next stage to the base of the transistor.

- In principle, the ckt. functions in the same manner as the Hazeltine neutralization ckt. with the advantage that the neutralizing capacitor, C_N does not have the supply voltage.

iii) Neutralization using coil

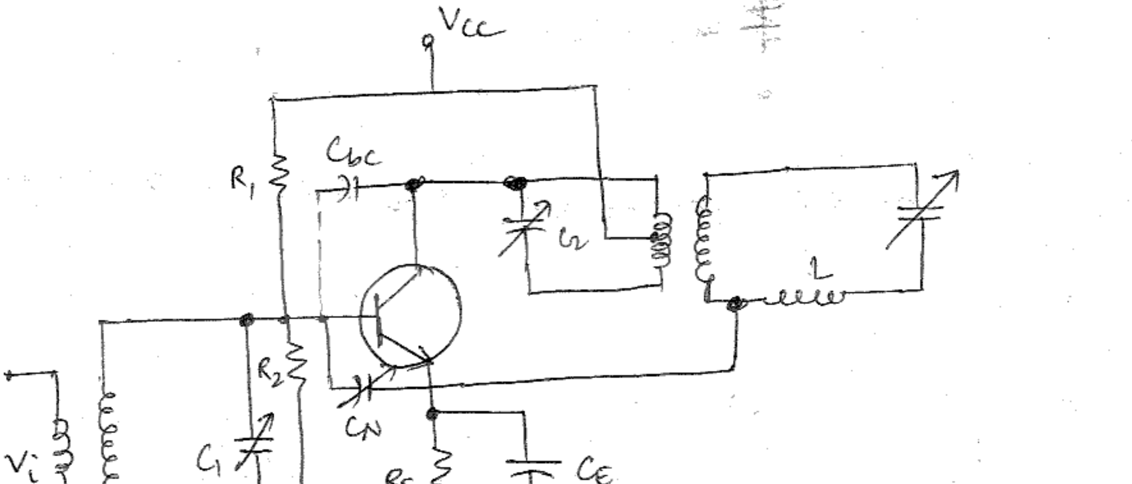


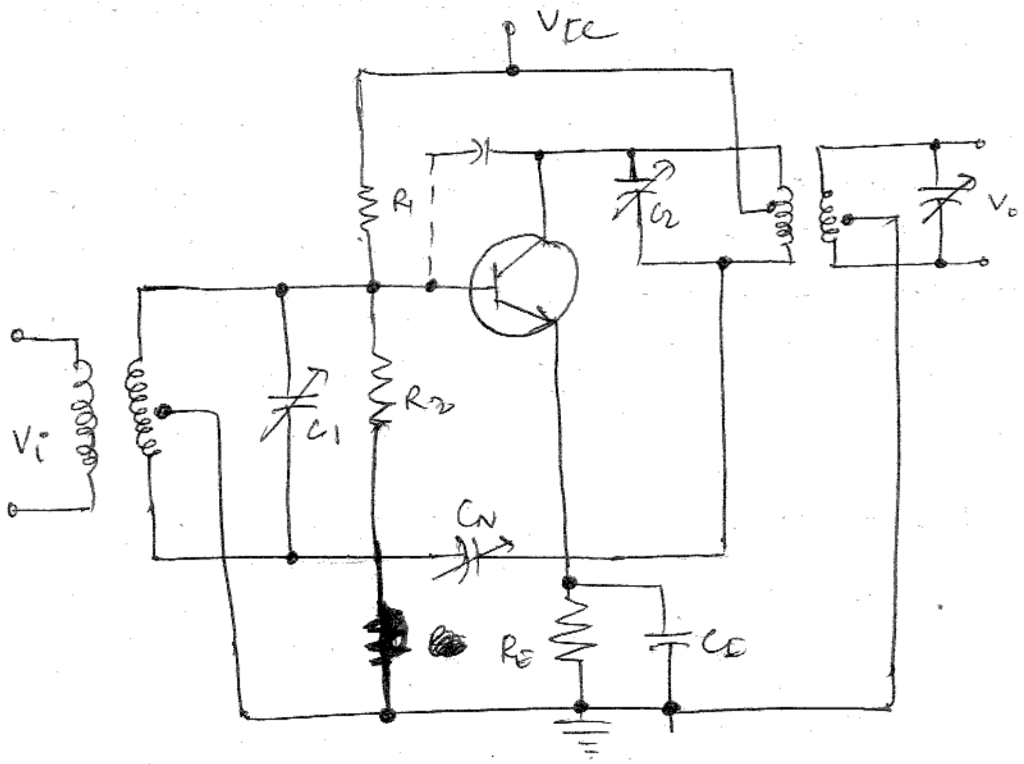
Fig. Tuned RF amplifier using coil.

- In this ckt; L part of the tuned ckt at the base of the next stage is oriented for minm coupling to the other windings.

- It is wound on a separate form and is mounted at right angles to the coupled windings.

- If the windings are properly polarized, the voltage across 'L' due to the circulating current in the base ckt. will have the proper phase to cancel the signal coupled through the base to collector, C_{bc} capacitance.

iv) Rice Neutralization.



Tuned RF amplifier using Rice neutralization.

- It uses a centre tapped coil in the base circuit.
- With this arrangement, the signal voltages at the ends of the tuned base coil are equal and out of phase.

Advantages	Disadvantages
i) They amplify defined frequencies.	i) The ckt is bulky and costly
ii) SNR at o/p is good.	ii) If the band of frequency is increased, design becomes complex.
iii) well suited for radio txr. & rxr.	iii) not suitable to amplify audio frequencies.
iv) The band of frequencies over which amplification is reqd can be varied.	

10 (a) (Instability of tuned amplifier)

Same as (9).

(b) Basic mixture circuit:

- Frequency conversion is the process of translating a modulated signal to a higher or lower freq. retaining all the originally transmitted information.

- Frequency conversion is a form of AM and often used before and after transmission or reception to provide some benefit.

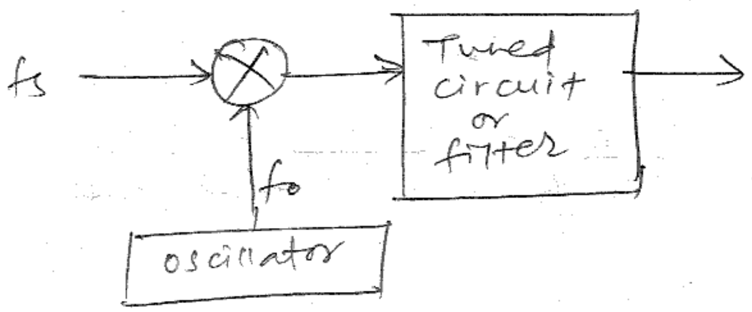


fig. Block schematic of mixer ckt.

- In above fig, the mixture accepts two i/ps

fs → which is to be translated to another freq. and

fo → sine wave from the oscillator.

- The mixture behaves like an amplitude modulator, performs mathematical multiplication of its two i/p signals and produces o/p signals i.e. fs, fo, fo+fs & fs−fo.

- Among those o/ps signals, only one is the desired one that's while tuned ckt. or filter is used at the o/p of the mixer to select the desired signal.

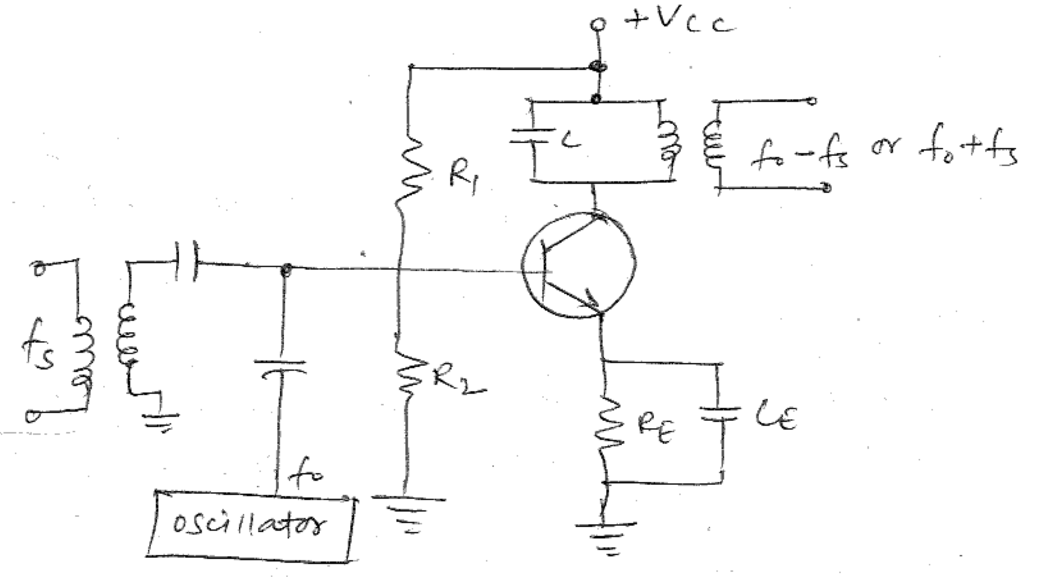


Fig. Mixer ckt using class C tuned amplifier.

- Here, transistor is biased to operate as a class C amplifier so that the collector current does not vary linearly with the base ~~of the~~ current

- This results in analog multiplication which produces the sum and difference frequencies.

- In fig. both the incoming signal & oscillator signal are applied to the base of the transistor.

- Finally, the tuned ckt. selects the sum or difference frequency at the o/p.

Applications :

1. In radio receivers, where the mixer is used to convert incoming signal to a lower freq. where it is easier to obtain the high gain & selectivity required.

2. Mixer circuits are used to translate signal frequency to some lower freq. or to some higher freq.
   - when it is used to translate signal to lower freq, it is called down converter, & when it is used to translate signal to higher freq, it is called up converter