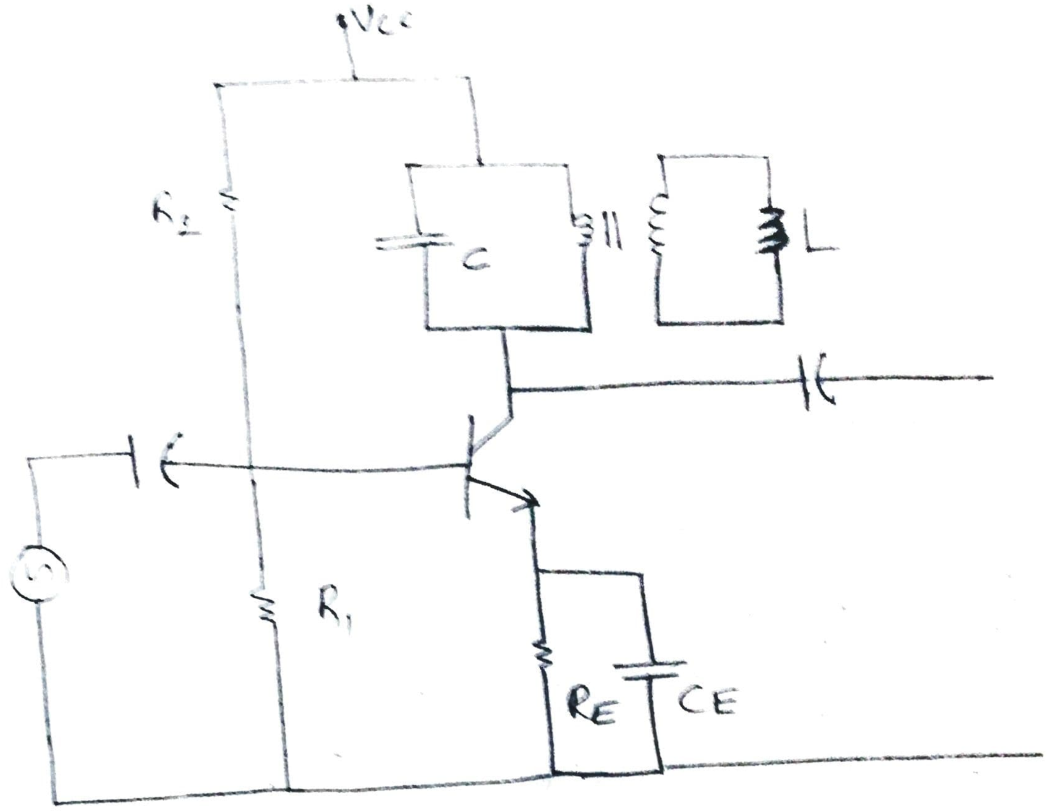
Inductor Coupled Single Tuned Amplifier

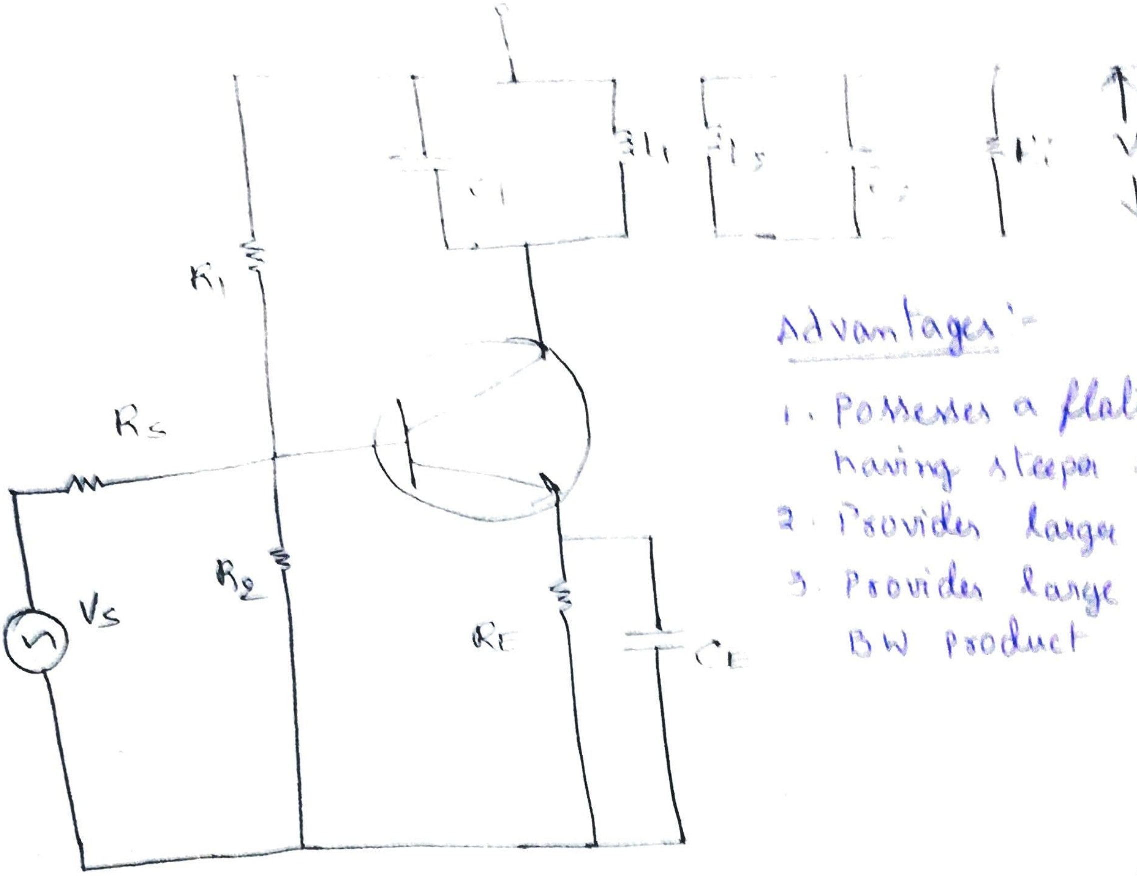



NOTE: 3dB Bandwidth of the inductively coupled single tuned amplifier is

$$\boxed{B.W. = \frac{f_o}{Q_{eff}}}$$

15/04/15

Double tuned amplifier



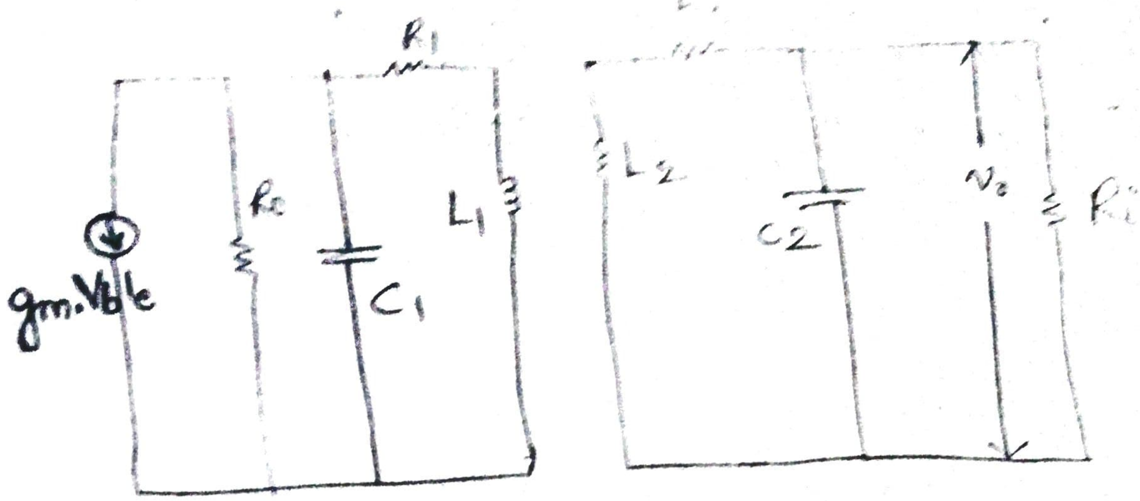

Advantages:-

1. Possesses a flatter response having steeper sides.
2. Provides larger 3dB BW
3. Provides large gain-BW product

Here, voltage developed across the tuned circuit is coupled inductively to another tuned circuit. Both tuned circuits are tuned to the same frequency.

## Analysis:

The following figure shows the equivalent circuit of coupling section of double tuned amplifier.




the transistor is replaced by current source with its output resistance Ro. $C_1$ & $L_1$ are the tank circuit components of the primary side, the resistance $R_1$ is the series resistance of the inductance $L_1$. Similarly, $C_2$ & $L_2$ represents the another tank circuit and $R_2$ represents the resistance of the inductance $L_2$. The resistance $R_i$ represents the input resistance of the next stage.

Effect of cascading single tuned amplifiers on Bandwidth:

In order to obtain the high overall gain, Several identical stages of tuned amplifiers can be used in cascade. when two or more identical stag are cascaded. These stages are said to be synchronously tuned. In synchronously tuned amplifiers, each stage is tuned to same frequency; the overall gain is the product of the voltage gains of individual stages.

Consider 'n' stages of single tuned direct coupled amplifiers connected in cascade, we know that the relative gain of the single tuned amplifier can be written as

$$\left|\frac{A_v}{A_{v(res)}}\right| = \frac{1}{\sqrt{1+(2\delta Q_{eff})^2}}$$

The relative gain of 'n' stage cascaded amplifiers become

$$\left|\frac{A_v}{A_{v(res)}}\right|^n = \left|\frac{1}{\sqrt{1+(2\delta Q_{eff})^2}}\right|^n = \frac{1}{\left[\sqrt{1+(2\delta Q_{eff})^2}\right]^n}$$

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

The 3dB frequency for $n$ stage cascaded amplifier can be found by equating

$$\left| \frac{A_v}{A_{v(res)}} \right|^n = \frac{1}{\sqrt{2}}$$

$$\left| \frac{A_v}{A_{v(res)}} \right| = \frac{1}{\left[1 + (2\delta Q_{eff})^2\right]^{n/2}} = \frac{1}{\sqrt{2}}$$

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

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

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

Substituting for $\delta$, the fractional frequency variation i.e. $\delta = \frac{\omega - \omega_r}{\omega_r} = \frac{f - f_r}{f_r}$

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

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

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

Let us assume, lower & upper side freq

be $f_1$ & $f_2$.

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

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

The bandwidth of 'n' stage identical amplifier is given as

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

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

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

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

$BW_1$ is the B.W of the single stage and $BW_n$ is the Bandwidth of 'n' stages.

16/04/17

The BW for Single-tuned amplifier is 20KHZ. ... the bandwidth of such 3 stages are cascaded ... Calculate the B.W for 4 stages.

$$BW_3 = 20KHZ \sqrt{2^{1/3}-1} = 10.1KHZ$$

$$BW_4 = 20KHZ \sqrt{2^{1/4}-1} = 8.7KHZ$$

$$BW_n = BW_1 \sqrt{2^{1/n}-1} \text{ for } n \text{ stages.}$$

The above example shows that band width decreases as number of stages increases.

## Effect of cascading Double Tuned Amplifiers on Bandwidth :

For 'n' identical stages of double tuned amplifiers, the 3dB bandwidth can be written as

$$BW_n = BW_1 \left(2^{1/n}-1\right)^{1/4}$$

$$\boxed{BW_n = \Delta_2 \left(2^{1/n}-1\right)^{1/4}}$$

where $\Delta_2$ is the 3dB bandwidth of single stage double tuned amplifier.

B[illegible] for [illegible] amplifier [illegible]
the bandwidth if such 3 stages are cascaded.

Sol) $BW_3 = 20\,KHZ\,(2^{1/3}-1)^{1/4} = 14.24\,KHZ$

## Staggered Tuned Amplifiers:

In this case, tuned circuit of ~~each case~~ each stage tuned to different frequencies.

### Analysis:

We know that, gain of the single tuned amplifier as

$$\left|\frac{A_v}{A_{v(res)}}\right| = \left|\frac{1}{\sqrt{1+(Q_{eff}\,2\delta)^2}}\right|$$

(or)

$$\frac{A_v}{A_{v(res)}} = \frac{1}{1+j2Q_{eff}\,\delta}$$

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

Since in staggered tuned amplifiers, the

In single tuned cascaded amplifiers when separate resonant frequencies are used, we can assume that the 1 stage is tuned to the frequency $f_r+\delta$ and other stage is tuned to the frequency $f_r-\delta$.

i.e.; $f_{r_1} = f_r + \delta$ & $f_{r_2} = f_r - \delta$

According to these tuned frequencies, the selectivity functions can be given as

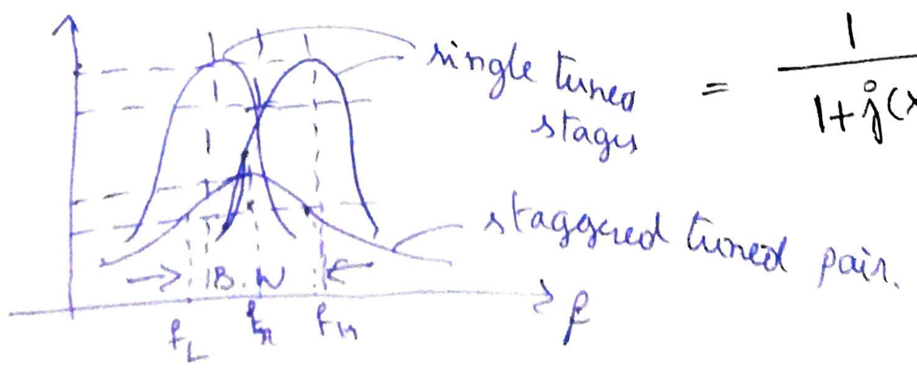
$$\frac{A_v}{A_{v(res)1}} = \frac{1}{1+j(X+1)}$$

$$\& \quad \frac{A_v}{A_{v(res)2}} = \frac{1}{1+j(X-1)}$$

The overall gain of these two stages is the product of individual gains of two stages i.e.;

$$\therefore \frac{A_v}{A_{v(res)Cascade}} = \frac{A_v}{A_{v(res)1}} \times \frac{A_v}{A_{v(res)2}}$$

$$= \frac{1}{1+j(X+1)} \cdot \frac{1}{1+j(X-1)}$$



$$\frac{A_v}{A_{v(res)\,cascade}} = \frac{1}{2 + 2jx - x^2} = \frac{1}{(2 - x^2) + (2jx)}$$

$$\left| \frac{A_v}{A_{v(res)\,Cascade}} \right| = \frac{1}{\sqrt{(2-x^2)^2 + (2x)^2}}$$

$$= \frac{1}{\sqrt{4 - \cancel{4x^2} + x^4 + \cancel{4x^2}}}$$

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

Sub. value of $x = 2Q_{eff}\,\delta$

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

$$\left| \frac{A_v}{A_{v(res)\,Cascade}} \right| = \frac{1}{2\sqrt{1 + 4Q_{eff}^4 \cdot \delta^4}}$$