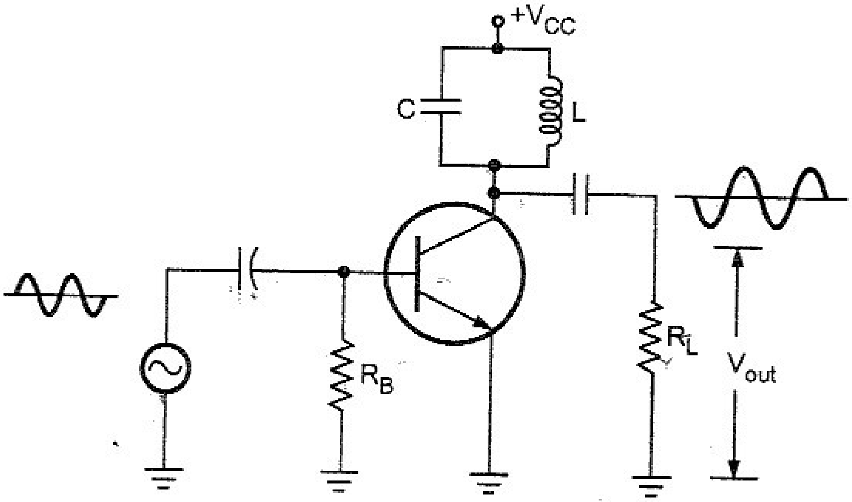

Fig. 3.27 Tuned class C amplifier

A class C tuned amplifier can be used as a frequency multiplier if the resonant circuit is tuned to a harmonic of the input signal.

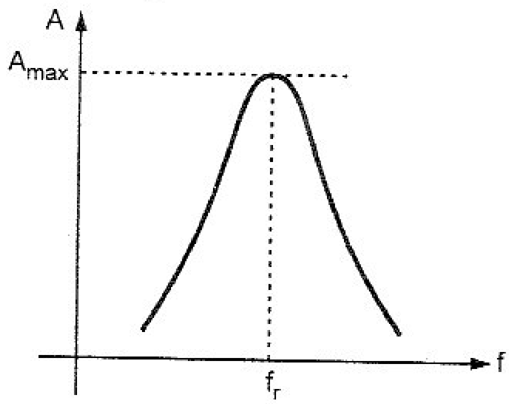

Fig. 3.28 Frequency response

Resonant frequency

Here, class C amplifier is used with parallel tuned circuit. Therefore, the output voltage is maximum at the resonant frequency. The resonant frequency for parallel tuned circuit is given as,

$$f_r = \frac{1}{2\pi\sqrt{LC}} \quad \dots (1)$$

Example 3.7 : *A class C tuned amplifier has inductance of 3 μH and capacitance of 470 pF in the tank circuit. Calculate the resonant frequency.*

Solution : We know that,

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{3\ \mu H \times 470\ pF}} = \mathbf{4.238\ MHz}$$

Now we will discuss a few equations that are useful in the analysis of class C amplifier.

Power gain

Power gain is defined as,

$$G = \frac{P_{out}}{P_{in}} \quad \dots (2)$$

In words, the power gain equals the a.c. output power divided by the a.c. input power.

Output power

If we measure the output voltage of Fig. 3.27 in r.m.s. volts, the output power is given by

$$P_{out} = \frac{V_{rms}^2}{R_L} \quad \dots (3)$$

Usually we measure the output voltage in peak to peak volts (V_{pp}) with an oscilloscope and

$$V_{pp} = 2\sqrt{2}\, V_{rms}$$

$$\therefore \quad V_{rms} = \frac{V_{pp}}{2\sqrt{2}}$$

Substituting value of V_{rms} we get,

$$P_{out} = \frac{\left(V_{pp} / 2\sqrt{2}\right)^2}{R_L} = \frac{V_{pp}^2}{8R_L} \quad \dots (4)$$

A.C. collector resistance

Any inductor has a series resistance R, as indicated in Fig. 3.29. The Q of the inductor is defined as,

$$Q_L = \frac{X_L}{R} = \frac{\omega_r L}{R} \quad \dots (5)$$

where Q_L = Quality factor of coil

X_L = Inductive reactance

R = Coil resistance

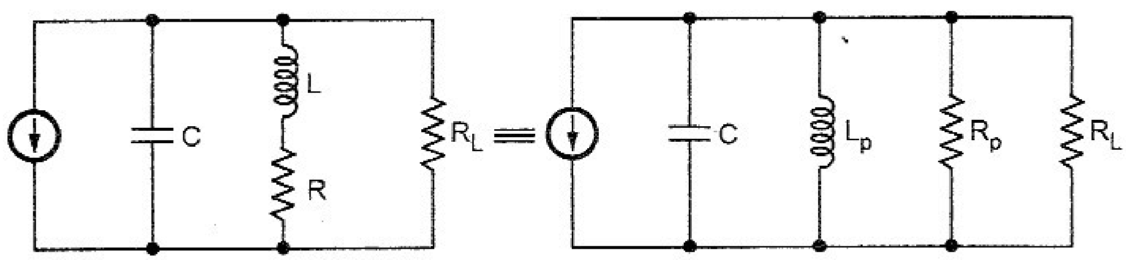

Fig. 3.29

As shown in the Fig. 3.29, the series resistance of the coil can be replaced by a parallel resistance R_p. This equivalent parallel resistance can be given as,

$$R_p = Q_L \omega_r L \quad \dots (6)$$

At resonance, X_L cancels X_C, leaving only R_p in parallel with R_L. Therefore, the a.c. resistance seen by the collector at resonance is :

$$r_c = R_p \parallel R_L \quad \text{... (7)}$$

$\therefore$ Q of the overall circuit is given by,

$$Q = \frac{r_c}{\omega_r L} \quad \text{... (8)}$$

Transistor power dissipation

Fig. 3.30 shows the ideal collector-emitter voltage in a class C transistor amplifier. In Fig. 3.30, the maximum output is given by,

$$V_{pp\,(max)} = 2\,V_{CC} \quad \text{... (9)}$$

Since the maximum voltage is approximately 2 V_{CC}, the transistor must have V_{CEO} rating greater than 2 V_{CC}.

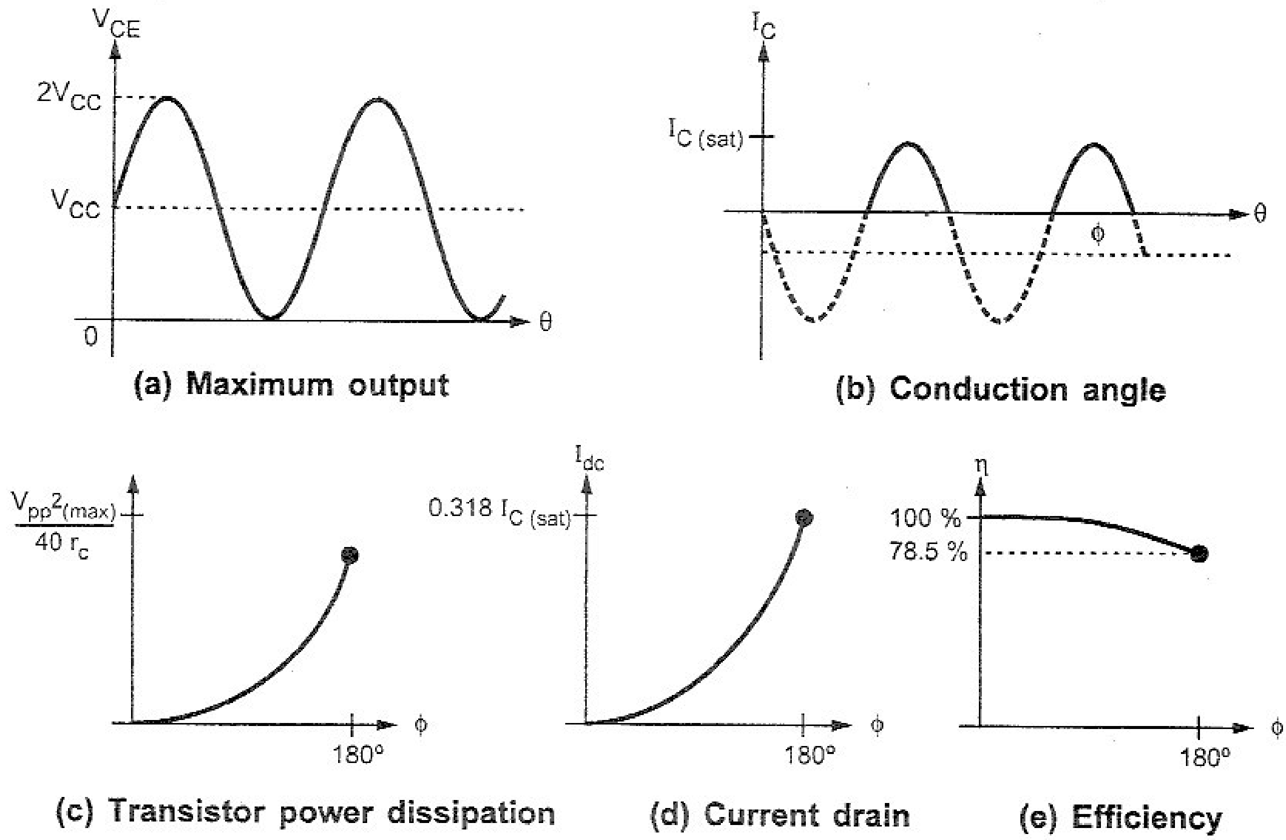

Fig. 3.30

Fig. 3.30 (b) shows the collector current for a class C amplifier. Typically, the conduction angle ϕ is much less than 180°. The power dissipation of the transistor depends on the conduction angle. It increases when conduction angle increases as shown in Fig. 3.30 (c). The maximum power dissipation for class C amplifier can be given as,

$$P_{D\,max} = \frac{V^2_{pp(max)}}{40 r_c} \quad \text{... (10)}$$

where r_c = A.C. collector resistance

Under normal condition, conduction angle will be less than 180° and the transistor power dissipation will be less than $V^2_{pp(max)}/40\ r_c$. But considering worst case condition, transistor power rating must be greater than $P_{D\,max}$.

D.C. input power

D.C. input power can be given as,

$$P_{dc} = V_{CC}\ I_{dc} \quad \ldots (11)$$

Efficiency

The efficiency of the amplifier is given as

$$\eta = \frac{P_{out}}{P_{dc}} \times 100\ \% = \frac{P_{out}}{V_{CC} \times I_{dc}} \times 100\ \% \quad \ldots (12)$$

The d.c. collector current depends on the conduction angle for a conduction angle of 180° (a half-wave signal), the average or d.c. collector current is $I_{C\,(sat)}/\pi$. For smaller conduction angles, the d.c. collector current is less than this, as shown in Fig. 3.30 (d).

In a class C amplifier, most of the d.c. input power is converted into a.c. load power because the transistor and coil losses are small. When the conduction angle is 180°, the efficiency is 78.5 %. The efficiency increases when conduction angle decreases. As indicated class C amplifier has maximum efficiency of 100 %, approached at very small conduction angles.

Bandwidth

We know that, bandwidth of resonant circuit is defined as

$$BW = f_2 - f_1$$

where f_1 = Lower half power (3 dB) frequency

f_2 = Upper half power (3 dB) frequency

The half power frequencies are identical to the frequencies at which the voltage gain equal 0.707 times the maximum gain.

The bandwidth of the class C tuned amplifier is given as,

$$BW = \frac{f_r}{Q} \quad \ldots (13)$$

where Q is the quality factor of the circuit,

Example 3.8 : *For the circuit shown in Fig. 3.31, calculate resonant frequency, ac collector resistance, quality factor and bandwidth. Assume $Q_L = 100$.*

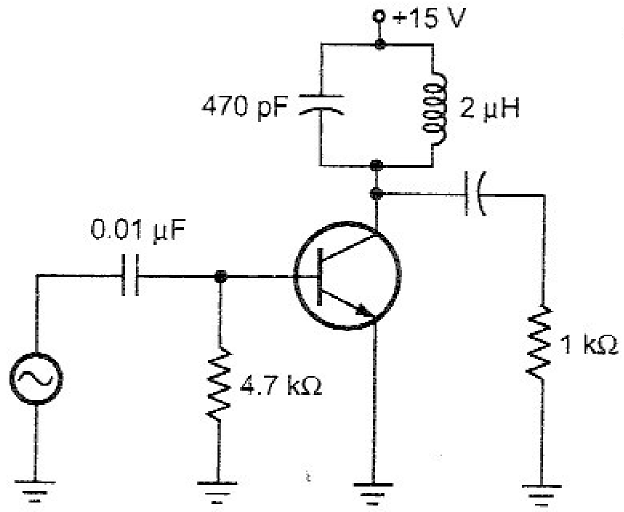

Fig. 3.31

Solution : i) Resonant frequency

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{2\ \mu H \times 470\ pF}} = \mathbf{5.19\ MHz}$$

ii) A.C. collector resistance is given as,

$$r_c = R_p \| R_L = Q_L\,\omega_r\,L \| R_L$$
$$= (Q_L\,2\pi f_r L) \| R_L$$
$$= (100 \times 2\pi \times 5.19 \times 10^6 \times 2\mu H) \| 1\,k\Omega$$
$$= 6.52\,k\Omega \| 1\,k\Omega = \mathbf{867\ \Omega}$$

iii) Quality factor of the overall circuit is given as,

$$Q = \frac{r_c}{\omega_r\,L} = \frac{r_c}{2\pi\,f_r\,L}$$
$$= \frac{867}{2\pi \times 5.19 \times 10^6 \times 2 \times 10^{-6}} = \mathbf{13.29}$$

iv) Bandwidth is given as,

$$BW = \frac{f_r}{Q} = \frac{5.19 \times 10^6}{13.29} = \mathbf{390.5\ kHz}$$

Example 3.9 : *For the circuit shown in example 3.8, what is the worst case power dissipation?*

Solution : The maximum peak to peak output is given as,

$$V_{pp(max)} = 2V_{CC} = 2 \times 15 = \mathbf{30\ V}$$

The worst case power dissipation (maximum power dissipation) of the transistor is given as,

$$P_{D(max)} = \frac{V_{pp}^2}{40 r_c} = \frac{30^2}{40 \times 867} = \mathbf{26\ mW}$$

Example 3.10 : *For the circuit shown in Fig. 3.32, calculate*

i) Output power if the output voltage is 50 V_{pp}.

ii) Maximum ac output power.

iii) D.C. input power if current drain is 0.5 mA.

iv) Efficiency if the current drain is 0.4 mA and the output voltage is 30 V_{pp}.

v) Bandwidth of amplifier if Q = 125.

vi) Worst case transistor power dissipation.

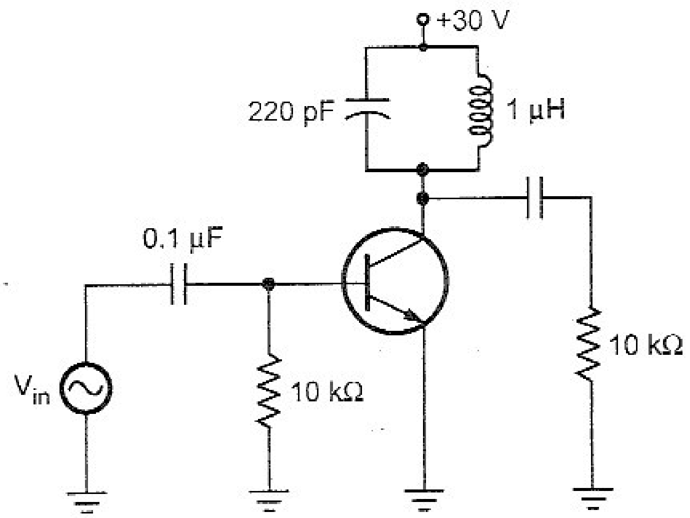

Fig. 3.32

Solution : i) The output power of amplifier is given as

$$P_{out} = \frac{(V_{out})^2}{8 R_L}$$

$$= \frac{(V_{pp})^2}{8 R_L} = \frac{(50)^2}{8 \times 10 K} = \mathbf{31.25\ mW}$$

ii) Maximum a.c. output power is given as,

$$P_{ac(max)} = \frac{\left(V_{pp(max)}\right)^2}{8 R_L} = \frac{(2 \times V_{CC})^2}{8 R_L}$$

$$= \frac{(60)^2}{8 \times 10 K} = \mathbf{45\ mW}$$

iii) D.C. input power is given as,

$$P_{dc} = V_{CC} \times I_{dc}$$

$$= 30 \times 0.5\,\text{mA} = \mathbf{15\ mW}$$

iv) Efficiency is given as,

$$\eta = \frac{P_{out}}{P_{dc}} \times 100$$

Given : $I_{dc} = 0.4$ mA, $V_{out} = V_{pp} = 30$ V

$$= \frac{\left(\frac{V_{pp}^{\ 2}}{8R_L}\right)}{V_{CC}\ I_{dc}} \times 100 = \frac{\frac{30^2}{8 \times 10\,K}}{30 \times 0.4\,\text{mA}} \times 100 = \mathbf{93.75\ \%}$$

v) Bandwidth of the amplifier is given as,

$$BW = \frac{f_r}{Q}$$

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

$$= \frac{1}{2\pi\sqrt{1\ \mu H \times 220\ pF}} = \mathbf{10.73\ MHz}$$

$$\therefore \quad BW = \frac{10.73}{125} = \mathbf{85.84\ kHz}$$

vi) Worst case transistor power dissipation is given as,

$$P_{D\,(max)} = \frac{\left(V_{pp(max)}\right)^2}{40\,r_c}$$

where $$r_c = R_p \parallel R_L$$

$$= Q_L\ \omega_r\ L \parallel R_L$$

$$= \left(125 \times 2\pi \times 10.73 \times 10^6 \times 1 \times 10^{-6}\right) \parallel 10 \times 10^3$$

$$= 8427.3 \parallel 10 \times 10^3 = 4573.27\Omega$$

$$\therefore \quad P_{D\,(max)} = \frac{(2 \times 30)^2}{40 \times 4573.27} = \mathbf{19.68\ mW}$$

Example 3.11 : *If class C tuned amplifier has R_L = 6 kΩ and required tank circuit Q = 80. Calculate the values of L and C of the tank circuit. Assume V_{CC} = 20 V, resonant frequency = 5 MHz and worst case power dissipation = 20 mW.*

Solution : We know that,

$$P_{D\,max} = \frac{(V_{pp\,max})^2}{40\, r_c} = \frac{(2\, V_{CC})^2}{40\, r_c}$$

$$\therefore \quad r_c = \frac{(2\, V_{CC})^2}{40 \times P_{D\,max}}$$

$$= \frac{(2 \times 20)^2}{40 \times 20\,\text{mW}} = \mathbf{2\ k\Omega}$$

We know that

$$r_c = R_p \parallel R_L$$

$$\therefore \quad \frac{1}{R_p} = \frac{1}{r_c} - \frac{1}{R_L}$$

$$= \frac{1}{2\,K} - \frac{1}{6\,K}$$

$$= 3.33 \times 10^{-4}$$

$$\therefore \quad R_p = \mathbf{3\ k\Omega}$$

We know that,

$$R_p = Q_L \times \omega_r \times L$$

$$= Q_L \times 2\pi \times f_r \times L$$

$$\therefore \quad L = \frac{R_p}{Q_L \times 2\pi \times f_r}$$

$$= \frac{3000}{80 \times 2\pi \times 5 \times 10^6} = \mathbf{1.19\ \mu H}$$

We know that

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

$$\therefore \quad C = \frac{1}{(2\pi)^2\, L\, f_r^2}$$

$$= \frac{1}{(2\pi)^2 \times 1.19 \times 10^{-6} \times (5 \times 10^6)^2} = \mathbf{851\ pF}$$

3.9.3 Application of Class C Tuned Amplifier

As an application of tuned amplifier we see the mixer or frequency converter circuit. Frequency conversion is the process of translating a modulated signal to a higher or lower frequency while still retaining all the originally transmitted information. Although modulation itself is a form of frequency translation, frequency conversion is often used before and after transmission or reception to provide some benefit.

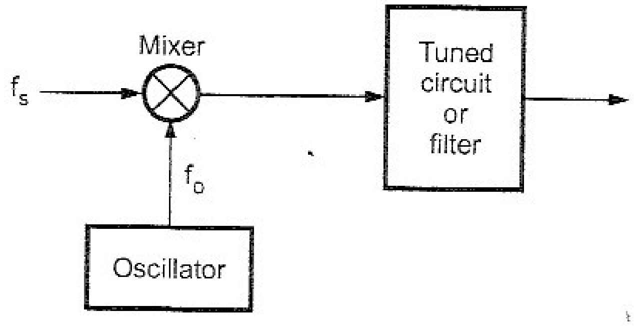

Fig. 3.33 Block schematic of mixer circuit

Frequency conversion is a form of AM. It is carried out by a mixer circuit. In some applications, the mixer is referred to as a converter. The function performed by the mixer is called heterodyning.

Fig. 3.33 shows the block schematic of mixer circuit. The mixer accepts two inputs : The signal f_s which is to be translated to another frequency and sine wave from the oscillator, f_o. The mixer, like an amplitude modulator, performs a mathematical multiplication of its two input signals and produces output signals : f_s , f_o , $f_o + f_s$ and $f_s - f_o$. Only one of these signals is the desired one. A tuned circuit or filter is normally used at the output of the mixer to select the desired signal.

The Fig. 3.34 shows the mixer circuit 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 variations in the base current. This results in analog multiplication which produces the sum and difference frequencies. As shown in the Fig. 3.34, both the incoming signal and oscillator signal are applied to the base of the transistor. The tuned circuit selects the sum or difference frequency.

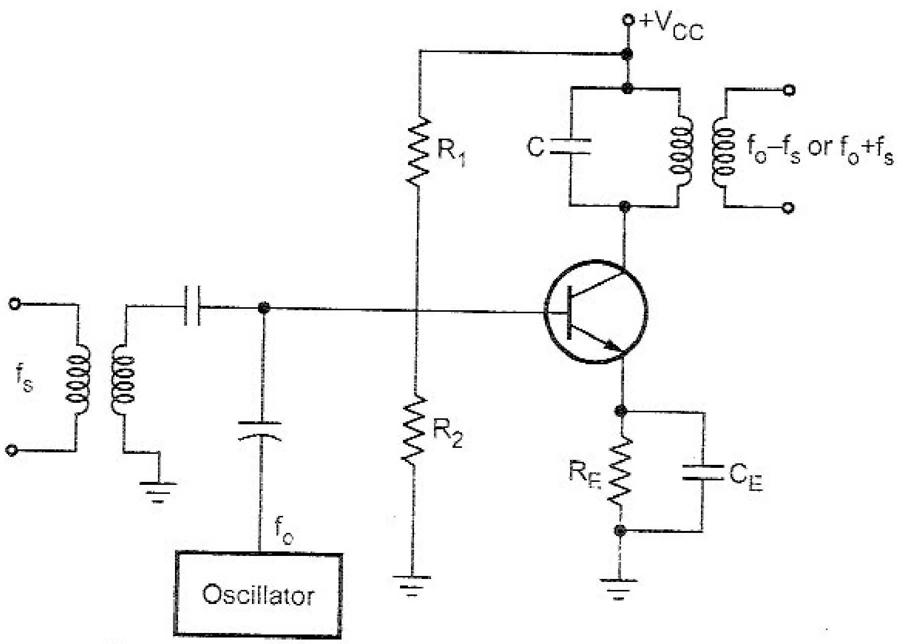

Fig. 3.34 Mixer circuit using class C turned amplifier

Applications of mixer or converter circuits

1. One of the most common applications for mixer is in radio receivers. The mixer is used to convert incoming signal to a lower frequency where it is easier to obtain the high gain and selectivity required.
2. Mixer circuits are used to translate signal frequency to some lower frequency or to some higher frequency. When it is used to translate signal to lower frequency it is called down converter. When it is used to translate signal to higher frequency, it is called up converter.

3.10 Stability of Tuned Amplifiers

In tuned RF amplifiers, transistors are used at the frequencies nearer to their unity gain bandwidths (i.e. f_T), to amplify a narrow band of high frequencies centred around a radio frequency. At this frequency, the inter junction capacitance between base and collector, C_{bc} of the transistor becomes dominant, i.e. its reactance becomes low enough to be considered, which is otherwise infinite to be neglected as open circuit. Being CE configuration capacitance C_{bc}, shown in the Fig. 3.35 come across input and output circuits of an amplifier. As reactance of C_{bc} at RF is low enough it provides the feedback path from collector to base. With this circuit condition, if some feedback signal manages to reach the input from output in a positive manner with proper phase shift, then there is possibility of circuit converted to an unstable one, generating its own oscillations and can stop working as an amplifier. This circuit will always oscillate if enough energy is fed back from the collector to the base in the correct phase to overcome circuit losses. Unfortunately, the conditions for best gain and selectivity are also those which promote oscillation. In order to prevent oscillations in tuned RF amplifiers it was necessary to reduce the stage gain to a level that ensured circuit stability. This could be accomplished in several ways such as lowering the Q of tune circuits; stagger tuning, loose coupling

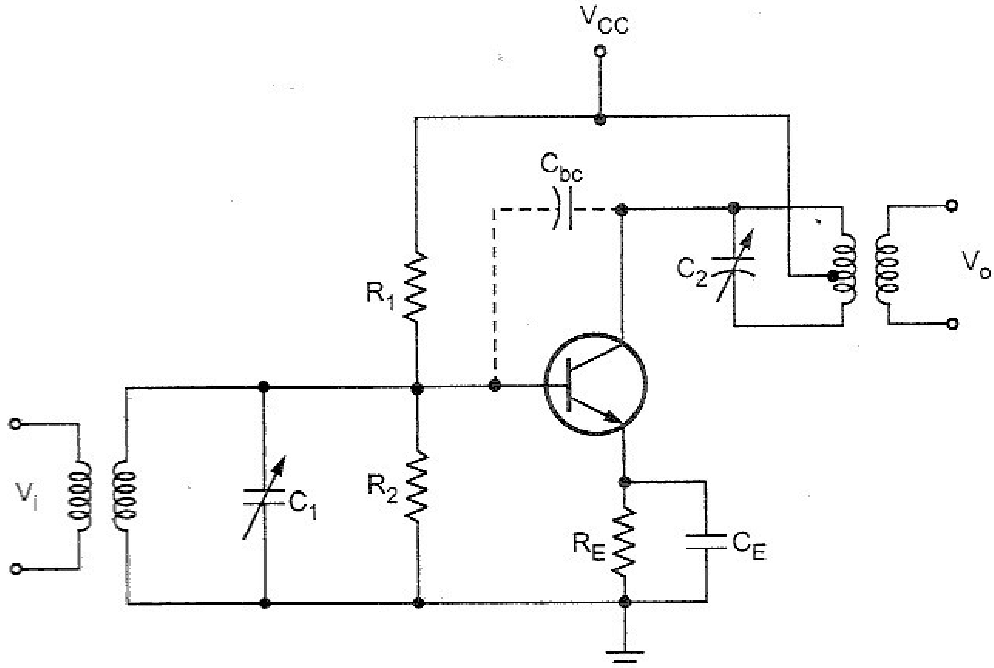

Fig. 3.35 Tuned RF stage

between the stages or inserting a 'loser' element into the circuit. While all these methods reduced gain, detuning and Q reduction had detrimental effects on selectivity. Instead of loosing the circuit performance to achieve stability, the professor L.A. Hazeltine introduced a circuit in which the troublesome effect of the collector to base capacitance of the transistor was neutralized by introducing a signal which cancels the signal coupled through the collector to base capacitance. He proved that the neutralization can be achieved by deliberately feding back a portion of the output signal to the input in such a way that it has the same amplitude as the unwanted feedback but the opposite phase. Later on many neutralizing circuits were introduced. Let us study some of these circuits.

3.10.1 Hazeltine Nèutralization

The Fig. 3.36 shows one variation of the Hazeltine circuit. 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}.

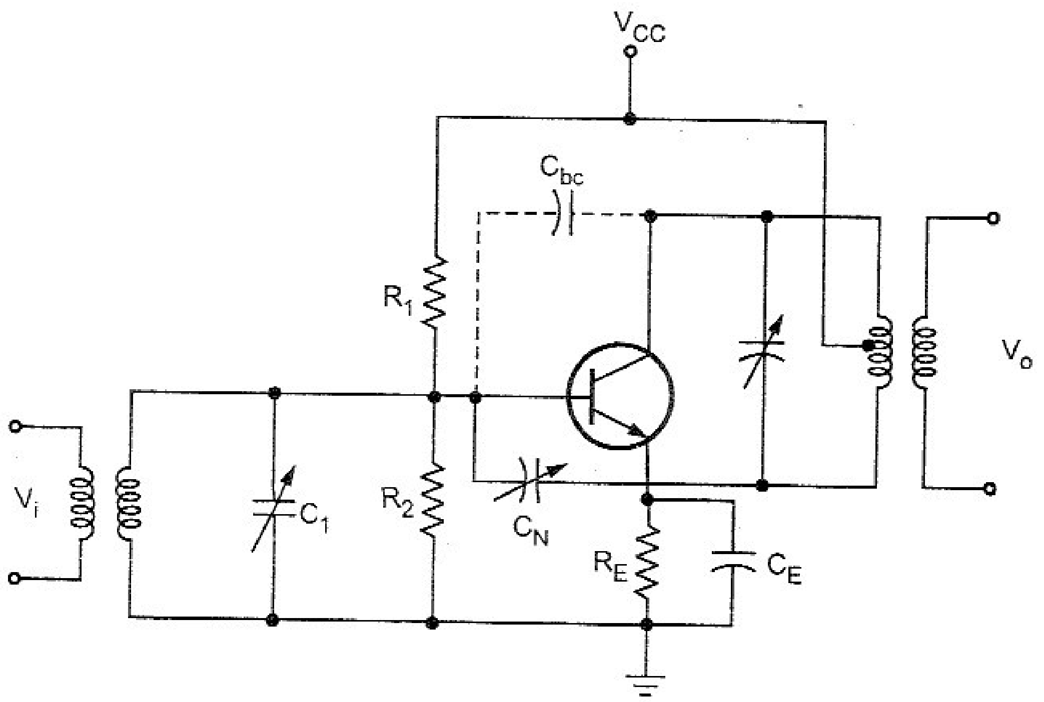

Fig. 3.36 Tuned RF amplifier with Hazeltine neutralization

3.10.2 Neutrodyne Neutralization

The Fig. 3.37 shows typical neutrodyne circuit. In this circuit 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, this circuit functions in the same manner as the Hazeltine neutralization circuit with the advantage that the neutralizing capacitor does not have the supply voltage across it.

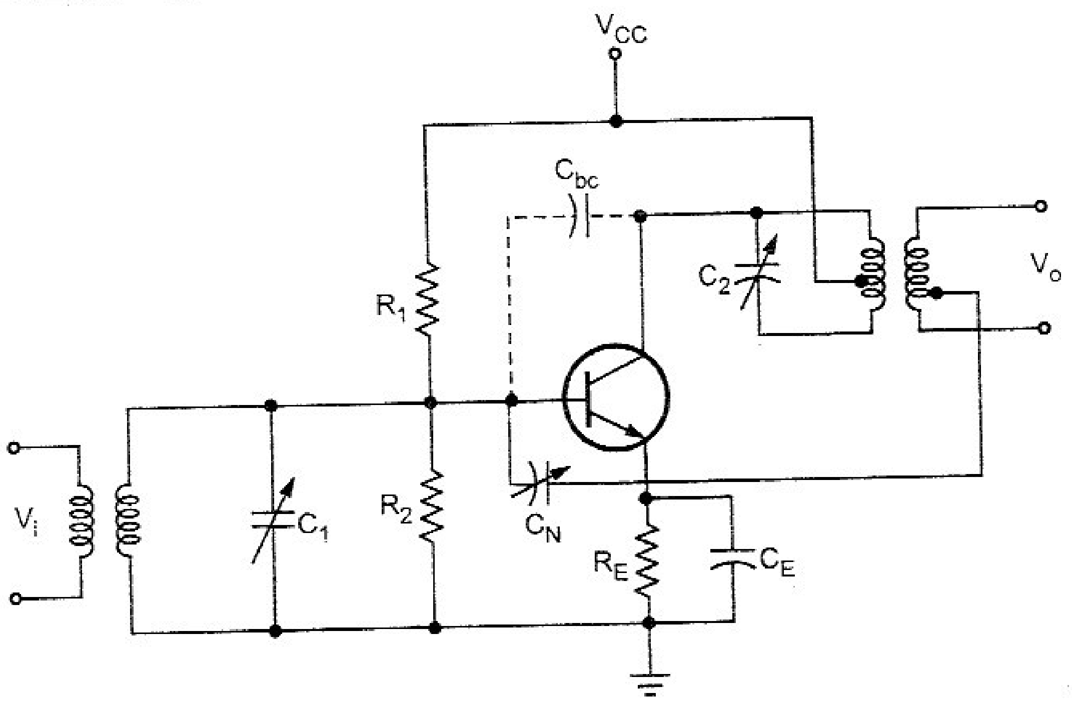

Fig. 3.37 Tuned RF amplifier with Neutrodyne neutralization

3.10.3 Neutralization using Coil

The Fig. 3.38 shows the neutralization of RF amplifier using coil. In this circuit, L part of the tuned circuit at the base of next stage is oriented for minimum 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 circuit will have the proper phase to cancel the signal coupled through the base to collector, C_{bc} capacitance.

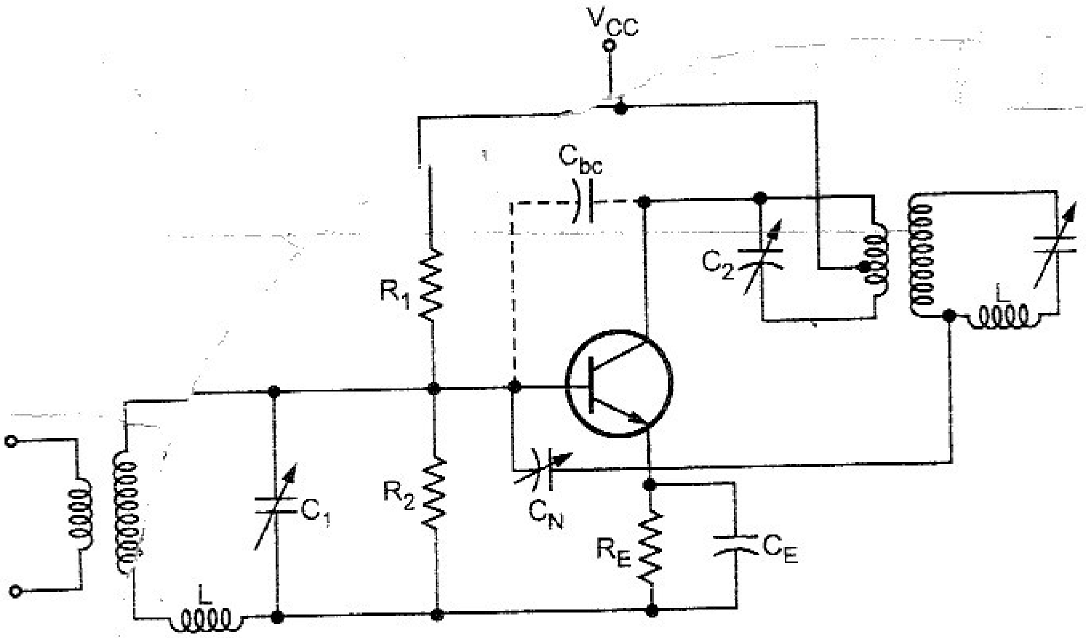

Fig. 3.38 Tuned RF amplifier using coil

3.10.4 Rice Neutralization

The Fig. 3.39 shows the Rice circuit of 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.

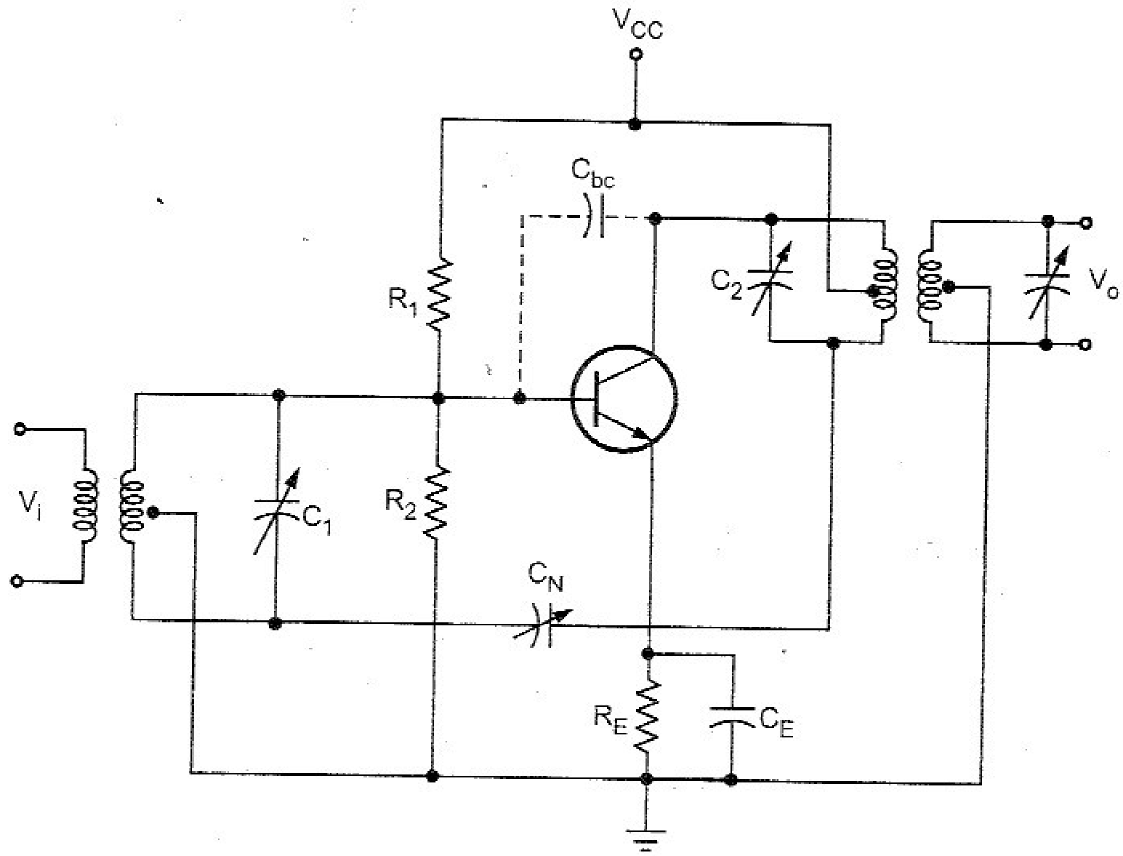

Fig. 3.39 Tuned RF amplifier using Rice neutralization

3.11 Advantages and Disadvantages of Tuned Amplifiers

Advantages :

1) They amplify defined frequencies.
2) Signal to noise ratio at output is good.
3) They are well suited for radio transmitters and receivers.
4) The band of frequencies over which amplification is required can be varied.

Disadvantages :

1) Since they use inductors and capacitors as tuning elements, the circuit is bulky and costly.
2) If the band of frequency is increased, design becomes complex.
3) They are not suitable to amplify audio frequencies.

3.12 Applications of Tuned Amplifiers

The important applications of tuned amplifiers are as follows :

1. Tuned amplifiers are used in radio receivers to amplify a particular band of frequencies for which the radio receiver is tuned.
2. Tuned class B and class C amplifiers are used as an output RF amplifiers in radio transmitters to increase the output efficiency and to reduce the harmonics.
3. Tuned amplifiers are used in active filters such as low pass, high pass and band pass to allow amplification of signal only in the desired narrow band.

Examples with Solutions

Example 3.12 : *Draw the single tuned amplifier using FET.*

Solution :

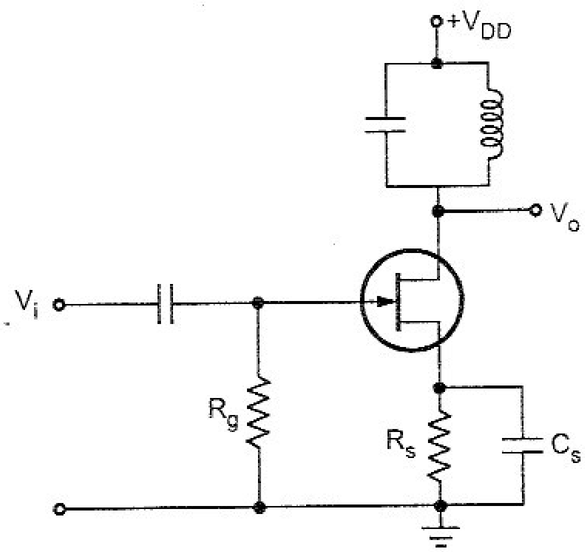

Fig. 3.40

Example 3.13 : *An RF tuned voltage amplifier, using FET with r_d = 100 kΩ and g_m = 500 μs has tuned circuit, consisting of L = 2.5 mH, C = 200 pF, as its load. At its resonant, frequency, the circuit offers an equivalent shunt resistance of 100 kΩ. For the amplifier determine,*

a) The resonant gain, b) The effective Q, c) The bandwidth.

Solution : Given : r_d = 100 K, g_m = 500 μs and tuned load of L = 2.5 mH and C = 200 pF

a) Resonant gain for FET amplifier can be given as,

$$A_v = -g_m R_L$$

where $R_L = r_d \parallel \text{Shunt resistance}$

$\therefore \quad A_v = -g_m (100 \text{ K} \| 100 \text{ K})$

$= -500\ 500 \times 10^{-6} \times 50 \times 10^3 = \mathbf{-25}$

b) The effective Q can be given as,

$$Q_{eff} = \frac{R_t}{\omega_r L}$$

where $R_t = 100 \text{ K} \| 100 \text{ K} = 50 \text{ K}$ and

$$\omega_r = 2\pi f_r$$

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{2.5\times10^{-3}\times200\times10^{-12}}}$$

$$= \frac{1}{4.44\times10^{-6}} \approx 225 \text{ kHz}$$

$$\therefore \quad Q_{eff} = \frac{R_t}{\omega_r L} = \frac{50 \text{ K}}{2\pi\times225\times10^3\times2.5\times10^{-3}} = \mathbf{14.147}$$

c) The bandwidth is given as,

$$BW = \frac{f_r}{Q_{eff}} = \frac{225\times10^3}{14.147} = \mathbf{15.904\ kHz}$$

Example 3.14 : *The transistor shown in Fig. 3.41 has h_{fe} = 50 and input resistance of 200 Ω.*

The coil used has Q factor = 30

Calculate : i) Resonant frequency of the tuned circuit.

ii) Impedance of the tuned circuit.

iii) Voltage gain of the stage.

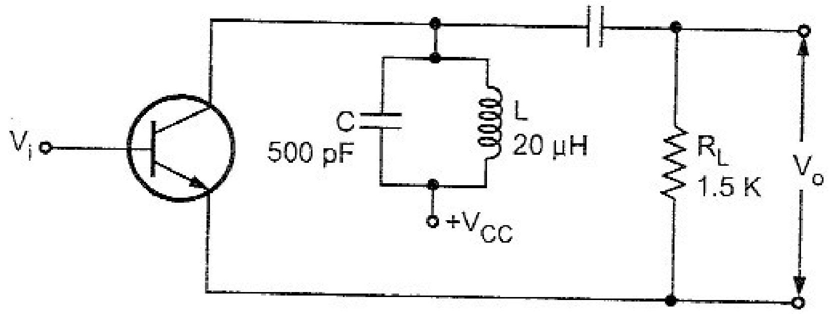

Fig. 3.41

Solution : i) Resonant frequency :

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{20\times10^{-6}\times500\times10^{-12}}}$$

$$= \frac{1}{2\pi \times 10^{-7}} = 0.159 \times 10^{7} \text{ Hz} = \mathbf{1.59\ MHz}$$

ii) We know that

$$Q_r = \frac{R_p}{\omega_r L}$$

$\therefore$ Impedance of tuned circuit R_p

$$= Q_r\, \omega_r\, L = 30 \times 2\pi \times 1.59 \times 10^{6} \times 20 \times 10^{-6} = \mathbf{5994\ \Omega}$$

iii) Voltage gain of stage A_v

$$A_v = \frac{A_I\, R'_L}{R'_i}$$

$$= \frac{-h_{fe}\,(R_p \,||\, R_L)}{R_i} = \frac{-50\,(5994 \,||\, 1.5\text{ K})}{200} = \mathbf{-300}$$

Example 3.15 : *A tuned amplifier should have a gain of 50 for a centre frequency of 10.7 MHz and bandwidth of 200 kHz. A FET with* g_m *= 5 mA/V and* r_d *= 100 K is to be used. Calculate the tank circuit parameters.*

Solution :

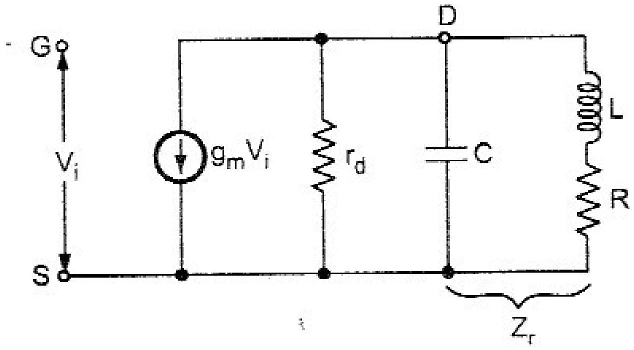

Fig. 3.42

$$f_r = \frac{1}{2\pi\sqrt{LC}} = 10.7 \text{ MHz} \qquad \dots (1)$$

$$\therefore \quad Q = \frac{f_r}{3\text{ dB (BW)}} = \frac{10.7\text{ MHz}}{200\text{ kHz}} = 53.5$$

$$\therefore \quad 53.5 = \frac{\omega_r\, L}{R} \qquad \dots (2)$$

$$A_v = -50 = -g_m\, R_L$$

$$\therefore \quad R_L = \frac{50}{5 \times 10^{-3}} = 10\text{ k}\Omega$$

where $R_L = r_d \parallel R_p$

$$\therefore \quad \frac{1}{R_L} = \frac{1}{r_d} + \frac{1}{R_p}$$

$$\therefore \quad \frac{1}{R_p} = \frac{1}{R_L} - \frac{1}{r_d} = \frac{1}{10\text{ K}} - \frac{1}{100\text{ K}}$$

$$\therefore \quad R_p = 11.11\text{ K}$$

We know that,

$$Q_r = \frac{R_p}{\omega_r L}$$

$$\therefore \quad L = \frac{R_p}{Q_r\,\omega_r} = \frac{11.11 \times 10^3}{53.5 \times 2 \times \pi \times 10.7 \times 10^6} = \mathbf{3.088\ \mu H}$$

We know that,

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

$$\therefore \quad C = \frac{1}{(2\pi f_r)^2\,L}$$

$$= \frac{1}{(2\pi \times 10.7 \times 10^6)^2 \times 3.088 \times 10^{-6}} = \mathbf{71.6\ pF}$$

We know that, $Q_r = \frac{\omega_r L}{R}$

$$\therefore \quad R = \frac{\omega_r L}{Q_r} = \frac{2\pi \times 10.7 \times 10^6 \times 3.088 \times 10^{-6}}{53.5} = \mathbf{3.88\ \Omega}$$

Example 3.16 : *A FET having g_m = 6 mA/V has a tuned anode load consisting of a 400 μH inductance of 5 Ω in parallel with a capacitor of 2500 pF. Find*

i) The resonant frequency.

ii) Tuned circuit dynamic resistance.

iii) Gain at resonance and

iv) The signal bandwidth.

Solution : i) f_r = Resonant frequency

$$= \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{400\ \mu H \times 2500\ pF}}$$

$$= \mathbf{0.159\ MHz}$$

ii) Tuned circuit dynamic resistance = $R_p = \frac{L}{CR}$

$$= \frac{400\ \mu H}{2500\ pF \times 5\ \Omega} = \frac{10^6 \times 80}{2500}$$

$$= 0.032 \times 10^6 = \mathbf{32\ k\Omega}$$

iii) Gain at resonance $= A_v = -g_m R_L = -g_m R_p$

$$= 6\ mA/V \times 32\ k\Omega = \mathbf{-192}$$

iv) The signal bandwidth = BW = $\frac{f_r}{Q}$

$$Q = \frac{\omega_r L}{R} = \frac{2\pi \times 0.159 \times 10^6 \times 400 \times 10^{-6}}{5\ \Omega}$$

$$= 79.92$$

$$BW = \frac{f_r}{Q} = \frac{0.159\ MHz}{79.92}$$

$$= \mathbf{1.98\ kHz}$$

Example 3.17 : *An RF amplifier of Fig. 3.43 uses FET having r_d = 500 kΩ and g_m = 5 mA/V.*

The drain tuned circuit consists of a coil of 200 μH and Q = 50 and parallel capacitance tuned to f_r = 1.59 MHz, find gain at,

i) The resonant frequency ω_r ii) A frequency 10 kHz higher than ω_r.

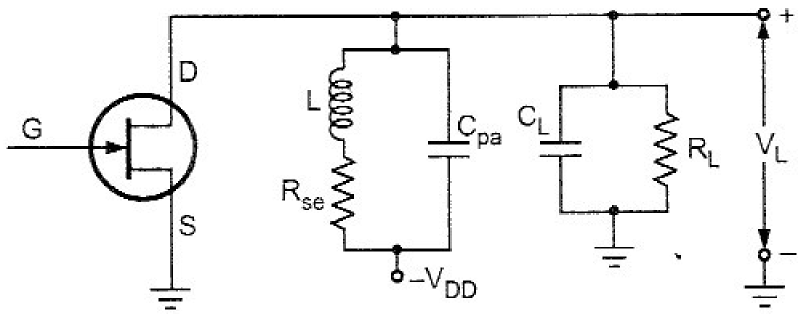

Fig. 3.43

Solution : i) $R_L = r_d \parallel R_p$

R_p = Tank circuit impedance at resonance = $\frac{L}{CR}$

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

$$\therefore \quad f_r^2 = \frac{1}{4\pi^2 LC}$$

$$\therefore \quad C = \frac{1}{4\pi^2 f_r^2 LC}$$

$$= \frac{1}{2\pi^2 (1.59 \times 10^6)^2 \times 200 \times 10^{-6}}$$

$$= 50 \times 10^{-12} \text{ F} = 50 \text{ pF}$$

$$`Q = \frac{\omega_r L}{R} = \frac{2\pi f_r L}{R}$$

$$R = \frac{2\pi f_r L}{R}$$

$$= \frac{2\pi \times (1.59 \times 10^6) \times 200 \times 10^6}{50} = 40 \ \Omega$$

$$R_p = \frac{L}{CR} = \frac{200 \times 10^{-6}}{50 \times 10^{-12} \times 40} = 100 \text{ K}$$

$$R_L = \frac{r_d R_p}{r_d + R_p}$$

$$= \frac{500 \times 10^3 \times 100 \times 10^3}{(500 + 100) \times 10^3} = 83.33 \times 10^3$$

$$A_v = -g_m R_L = 5 \times 10^{-3} \times 83.33 \times 10^3$$

A_v = **416.67** at resonance frequency ω_r

ii) At $f = f_r + 10 \text{ kHz} = 1.6 \text{ MHz}$

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

$$\therefore \quad |A_v| = \frac{|A_v (\text{at resonance})|}{\sqrt{1 + \left(\frac{f}{f_r} \right)^2}} = \frac{416.67}{\sqrt{1 + \left(\frac{1.6}{1.59} \right)^2}}$$

$$= \mathbf{293.7}$$

Example 3.18 : *A single tuned amplifier using FET has tank circuit components L = 100 μH, R = 5 Ω and C = 1000 pF. The FET used has r_d = 500 kΩ and g_m = 5 mA/V find*

i) Resonant frequency.

ii) Tank circuit impedance at resonance.

iii) Voltage gain at resonance and

iv) Bandwidth.

Solution : i) Resonant frequency $f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{100\ \mu H \times 1000\ pF}}$

$$= \mathbf{503.29\ kHz}$$

ii) Tank circuit impedance at resonance can be given as

$$R_p = \frac{L}{CR} = \frac{100\ \mu H}{1000\ pF \times 5}$$

$$= \mathbf{20\ K}$$

iii) $$A_v = -g_m R_L = -g_m (r_d \parallel R_p) = -5\ mA/V\ (500\ K \parallel 20\ K)$$

$$= \mathbf{-96.15}$$

iv) $$BW = \frac{f_r}{Q}$$

$$= \frac{f_r R}{\omega_r L} \qquad \therefore\ Q = \frac{\omega_r L}{R}$$

$$= \frac{R}{2\pi L} = \frac{5}{2\pi \times 100 \mu H} = \mathbf{7.957\ kHz}$$

Example 3.19 : *A tuned amplifier is required to have a voltage gain of 30 at 10.7 MHz with 200 kHz B.W. An FET with g_m = 5 mA/V and r_d = 100 kΩ is available. Calculate values of tank circuit elements.*

Solution : Given : $|A_v|$ = 30, f_r = 10.7 MHz

BW = 200 kHz, g_m = 5 mA/V and r_d = 100 kΩ

$$BW = \frac{f_r}{Q} \quad \therefore\ Q = \frac{f_r}{BW} = \frac{10.7\ MHz}{200\ kHz} = 53.5$$

$$Q = \frac{\omega_r L}{R} = \frac{2\pi f_r L}{R}$$

$$\therefore \quad \frac{L}{R} = \frac{Q}{2\pi f_r} = \frac{53.5}{2\pi \times 10.7\ MHz} = 795 \times 10^{-9}$$

$$|A_v| = g_m R_L = 30$$

$$\therefore \quad R_L = (r_d || R_p) = \frac{30}{5 \text{ mA/V}} = 6 \text{ K}$$

$$\therefore \quad 100 \text{ K} || R_p = 6 \text{ K}$$

$$\therefore \quad R_p = 6383 \ \Omega$$

We know that,

$$R_p = \frac{L}{CR} = \frac{1}{C} \times 795 \times 10^{-9}$$

$$\therefore \quad C = \frac{795 \times 10^{-9}}{R_p} = \frac{795 \times 10^{-9}}{6383}$$

$$= \mathbf{124.5 \ pF}$$

We know that

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

$$\therefore \quad 10.7 \times 10^6 = \frac{1}{2\pi \sqrt{L \times 124.5 \text{ pF}}}$$

$$\therefore \quad L = \mathbf{1.777 \ \mu H}$$

We have

$$R_p = \frac{L}{CR}$$

$$\therefore \quad R = \frac{L}{CR_p} = \frac{1.777 \ \mu\text{H}}{124.5 \text{ pF} \times 6383}$$

$$= \mathbf{2.236 \ \Omega}$$

Therefore, elements of tank circuits are :

L = 1.777 μH, C = 124.5 pF and R = 2.236 Ω .

Review Questions

1. *What do you mean by tuned amplifiers ?*
2. *Write a short note on coil losses.*
3. *Define Q.*
4. *What do you mean by unloaded Q and loaded Q ?*
5. *What are the requirements of tuned amplifier ? Classify tuned amplifiers.*
6. *Draw and explain the working of single tuned amplifier.*
7. *Derive an expression for tuning frequency of a single tuned amplifier interms of quality factor and bandwidth of the amplifier.*
8. *What is the effect of cascading single tuned amplifiers on bandwidth ? Derive the expression for it.*

9. *Draw and explain the circuit of double tuned amplifier with the help of frequency response.*
10. *What is the effect of cascading double tuned amplifiers on bandwidth ?*
11. *Discuss advantages and disadvantages of tuned amplifiers.*
12. *A single tuned RF amplifier uses a transistor with an output resistance of 60 K, output capacitance of 20 pF and input resistance of next stage is 20 kΩ. The tuned circuit consists of 47 pF capacitance in parallel with series combination of 1 μH inductance and 4 Ω resistance. Calculate*

    a) Resonant frequency.

    b) Effective quality factor.

    c) Bandwidth of the circuit. **(Ans. : i) f_r = 19.44 MHz ii) Q_{eff} = 40.76 iii) BW = 476.93 kHz)**
13. *A single tuned transistor amplifier is used to amplify modulated RF carrier of 500 kHz and bandwidth of 20 kHz. The circuit has a total output resistance, R_t = 40 kΩ and output capacitance C_o = 50 pF. Calculate values of inductance and capacitance of the tuned circuit.* **(Ans. : L = 509 μH , C = 148.94 pF)**
14. *The bandwidth for single tuned amplifier is 25 kHz. Calculate the bandwidth if such three stages are cascaded. Also calculate the bandwidth for four stages.* **(Ans. : i) BW_3 = 12.74 kHz ii) BW_4 = 10.87 kHz)**
15. *The bandwidth for double tuned amplifier is 10 kHz. Calculate the bandwidth if such three stages are cascaded.* **(Ans. : BW_3 = 7.14 kHz)**
16. *A three stage double tuned amplifier system is to have a half power BW of 30 kHz centred on a centre frequency of 400 kHz. Assuming that all stages are identical, determine the half power bandwidth of single stage. Assume that each stage couple to get maximum flatness.* **(Ans. : BW = 42 kHz)**
17. *State the applications of tuned amplifiers.*
18. *What is stagger tuning ?*
19. *Explain the frequency response of stagger tuned pair.*
20. *Write a short note on class B tuned amplifier.*
21. *Draw and explain the working of class C tuned amplifier.*
22. *Draw and explain the basic mixer circuit.*
23. *Draw the circuit diagram of a class C transistor mixer circuit and describe its operation. List few applications of the circuit.*
24. *How class C tuned amplifier is used as frequency multiplier ?*
25. *Draw the circuit diagrams of class C tuned amplifiers.*
26. *Discuss the instability of tuned amplifiers.*
27. *Explain the stabilization techniques used in tuned amplifiers.*
28. *What do you mean by neutralization ?*
29. *Explain the Hazeltine neutralization circuit with the help of neat diagram.*
30. *Explain various neutralization techniques.*

University Questions with Answers

Q.1 *What do you mean by tuned amplifier?*

Ans. : The amplifiers which amplifies only selected range of frequencies with the help of tuned circuits are called tuned amplifiers.

Q.2 *Give the expressions for resonance frequency and impedance of the tuned circuit.*

Ans. :

$$f_r = \frac{1}{2\pi\sqrt{LC}} \quad \text{and} \quad Z_r = \frac{L}{CR}$$

Q.3 *Response of tuned amplifiers is ____________ at resonant frequency and it ______ sharply for frequencies below and above the resonant frequency.*

Ans. : Maximum, falls.

Q.4 *For frequencies above resonance circuit is like ____________ and for frequencies below resonance it is like ___________.*

Ans. : Capacitive, inductive.

Q.5 *What are the various components of coil losses?*

Ans. :

- Copper loss
- Eddy current loss
- Hysteresis loss

Q.6 *Define Q factor.*

Ans. : The Q is the ratio of reactance to resistance. The Q factor also can be defined as the measure of efficiency with which inductor can store the energy.

Q.7 *What is dissipation factor ?*

Ans. : The **dissipation factor** (D) that can be referred to as the total loss within a component is defined as 1/Q.

Q.8 *Define unloaded and loaded Q of tuned circuit.*

Ans. : Unloaded Q is the ratio of stored energy to dissipated energy in a reactor or resonator.

The loaded Q or Q_L, of a resonator is determined by how tightly the resonator is coupled to its terminations.

Q.9 *Why quality factor is kept as high as possible in tuned circuit?*

Ans. : When quality factor is high inductor losses are less. Another important point is that when Q is high, bandwidth is low and we get better selectivity. Hence Q is kept as high as possible in tuned circuits.

Q.10 *List various types of tuned amplifiers.*

Ans. :
- Single tuned
- Double tuned
- Stragger tuned
- Synchronously tuned

Q.11 *Draw the circuit diagram of single tuned amplifier.*

Ans. : Refer Fig. 3.2.

Q.12 *What is synchronously tuned amplifier ?*

Ans. : In order to obtain a high overall gain, several identical stages of tuned amplifiers can be used in cascade. The overall gain is the product of the voltage gains of the individual stages. All amplifier stages are assumed to be identical and to be tuned to the same frequency, ω_0. This is called **synchronous tuning** and amplifier is called **synchronously tuned amplifier.**

Q.13 *What is the effect of cascading single tuned amplifiers on bandwidth?*

Ans. : Bandwidth reduces.

Q.14 *List the advantages and disadvantages of tuned amplifiers.*

Ans. : Refer section 3.11.

Q.15 *What is meant by unloaded and loaded Q of tank circuit ?* **[April/May-2003, 2 Marks]**

Ans. : Refer answer of Q.8.

Q.16 *Mention the applications of class C tuned amplifier.* **[April/May-2003, 2 Marks]**

Ans. : Refer section 3.9.3.

Q.17 *What is narrow band neutralization ?* **[Nov./Dec.-2003, 2 Marks]**

Ans. : A process of cancelling the instability effect due to the collector to base capacitance of the transistor in tuned circuits by introducing a signal which cancels the signal coupled through the collector to base capacitance is called narrow band neutralization.

Q.18 *Obtain the bandwidth of a n-stage cascaded identical single tuned amplifiers interms of the bandwidth of a single stage single tuned amplifier.* **[Nov./Dec.-2003, 8 Marks]**

Ans. : Refer section 3.6.

Q.19 *How class C tuned amplifier is used as frequency multiplier?* **[Nov./Dec.-2003, 4 Marks]**

Ans. : Refer section 3.9.

Q.20 *Indicate how coil neutralization technique is implemented in tuned amplifiers.*
[April/May-2004, 2 Marks]

Ans. : Refer section 3.10.

Q.21 *Determine the bandwidth of a 3 stage cascaded single tuned amplifier if the resonant frequency is 455 kHz and the loaded Q of each stage is 10.* **[April/May-2004, 2 Marks]**

Ans. :

$$Bw = \frac{fr}{Q} = \frac{455 \text{ kHz}}{10} = 45.5 \text{ kHz}$$

$$Bw_3 = 45.5 \times 10^3 \sqrt{2^{1/3} - 1} = 23.2 \text{ kHz}$$

Q.22 *A tank circuit contains an inductance of 1 mH. Find out the range of tuning capacitor value if the resonant frequency ranges from 540 kHz to 1650 kHz.*
[April/May-2004, 4 Marks]

Ans. : **For f_r = 540 kHz**

$$f_r = \frac{1}{2\pi\sqrt{LC}} \qquad \therefore 540 \text{ kHz} = \frac{1}{2\pi\sqrt{1 \times 10^{-3} \times C}}$$

$$\therefore \quad C = \mathbf{86.86 \text{ pF}}$$

For f_r = 1650 kHz

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{1 \times 10^{-3} \times C}} = 1650 \times 10^3$$

$$\therefore \quad C = \mathbf{9.3 \text{ pF}}$$

Q.23 *Explain how class C operation is used for frequency multiplication.*
[April/May-2004, 4 Marks]

Ans. : Refer section 3.9.

Q.24 *With circuit diagram, a.c. equivalent circuit and frequency response characteristics, explain the operation of a single tuned amplifier.* **[Nov./Dec.-2004, 8 Marks]**

Ans. : Refer section 3.2.

Q.25 *A resonant circuit has C = 120 pF, L = 100 μH (with a series resistance of 5 ohms). Find the Q factor and the bandwidth of the circuit.* **[Nov./Dec.-2004, 4 Marks]**

Ans. :

$$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{100 \times 10^{-6} \times 120 \times 10^{-12}}}$$

$$= 1.4528 \text{ MHz}$$

$$\omega_0 = 2\pi f_0 = 9.128 \times 10^6$$

$$Q = \frac{\omega_0 L}{R_s} = \frac{9.128 \times 10^6 \times 100 \times 10^{-6}}{5}$$

$$= 182.57$$

$$BW = \frac{f_0}{Q} = \frac{1.4528 \times 10^6}{182.57} = 7.957 \text{ kHz}$$

Q.26 *What is the effect of cascading n stages of identical single tuned amplifiers (synchronously tuned) on the overall 3 dB bandwidth ?* **[Nov./Dec.-2004, 4 Marks]**

Ans. : $$BW_n = BW_1 \sqrt{2^{1/n} - 1}$$

Q.27 *If the resonant frequency and the effective loaded Q of a single tuned amplifier are 600 kHz and 10 respectively, calculate the bandwidth of a 3 stage cascaded synchronously tuned single tuned amplifier.* **[April/May-2005, 2 Marks]**

Ans. : $$BW = \frac{f_0}{Q} = \frac{600 \times 10^3}{10} = 60 \text{ kHz}$$

$$BW_3 = BW \times \sqrt{2^{1/3} - 1}$$

$$= 60 \times 10^3 \times 0.509$$

$$= \mathbf{30.589 \text{ kHz}}$$

Q.28 *A single tuned amplifier using n channel JFET with $g_m = 5$ mA/V and $r_d = 20$ kΩ, has tank circuit with L = 1 mH, series resistance of the coil $R_s = 25$ Ω and C = 1 nF. Calculate the voltage gain at resonance if $R_L = 32$ kΩ.* **[April/May-2005, 2 Marks]**

Ans. : $$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{1 \times 10^{-3} \times 1 \times 10^{-9}}} = \mathbf{159.15 \text{ kHz}}$$

$$R_p = \frac{\omega^2 L^2}{R_s} = \frac{(2\pi \times 159.15 \times 10^3)^2 \times (1 \times 10^{-3})^2}{25} = \mathbf{40 \text{ k}\Omega}$$

$$A_v = g_m R$$

$$= 5 \times 9.4 = 47$$

where $$R = r_d \parallel R_p \parallel R_L = 20 \text{ K} \parallel 40 \text{ K} \parallel 32 \text{ K} = \mathbf{9.4 \text{ K}}$$

Q.29 *What is the effect of Q on the resonance circuit ?* **[Nov./Dec.-2005, 2 Marks]**

Ans. : Refer section 3.1.2.

Q.30 *Discuss briefly about neutralization in tuned amplifiers.* **[Nov./Dec.-2005, 2 Marks]**

Ans. : Refer section 3.10.

Q.31 *An inductor of 250 μH has Q = 300 at 1 MHz. Determine R_s and R_p of inductor.* **[May/June-2006, 2 Marks]**

Ans. : $$R_p = \omega_0 \cdot LQ = 2\pi \times 1 \text{ MHz} \times 250 \times 10^{-6} \times 300$$

$$= \mathbf{471.24 \text{ k}\Omega}$$

$$R_s = \frac{\omega_0 L}{Q} = \frac{2\pi \times 10^6 \times 250 \times 10^{-6}}{300}$$

$$= \mathbf{5.235\ \Omega}$$

Q.32 *Draw a class C tuned amplifier circuit and what is its efficiency.*

[May/June-2006, 2 Marks]

Ans. : Refer section 3.9.

Q.33 *Derive the bandwidth of a synchronous tuning system with three single tuned amplifiers. Assume bandwidth of individual stage is 10 kHz.*

[May/June-2006, 6 Marks]

Ans. :

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

$$= 10 \times 10^3 \sqrt{2^{1/3} - 1} = \mathbf{5.095\ kHz}$$

Q.34 *With equivalent circuit of single tuned amplifier derive the gain as function of frequency. Derive the cut-off frequencies.* **[May/June-2006, 10 Marks]**

Ans. : Refer section 3.2.

Q.35 *What is the need for neutralization ? Explain Hazeltine neutralization.*

[May/June-2006, 6 Marks]

Ans. : Refer section 3.10.

Q.36 *Design a tuned amplifier using FET to have f_o = 1 MHz, 3 dB bandwidth is 10 kHz and maximum gain is – 10 FET has g_m = 5 mA/V, r_d = 10 K.*

[May/June-2006, 10 Marks]

Ans. : The maximum gain of the amplifier is given by,

$$A_{i(max)} = -g_m R$$

$$\therefore \quad R = -\frac{(-10)}{5\,mA/V} = 2 \times 10^3\ \Omega$$

The 3 dB bandwidth of the amplifier is given by,

$$BW = \frac{1}{2\pi RC}$$

$$\therefore \quad C = \frac{1}{2\pi R\,BW} = \frac{1}{2\pi \times 2 \times 10^3 \times 10 \times 10^3}$$

$$= \mathbf{7.957\ nF}$$

The resonant frequency is given by,

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$\therefore \quad 1 \times 10^6 = \frac{1}{2\,p\sqrt{L \times 7.957 \times 10^{-9}}}$$

Q.40 *Explain Hazeltine neutralization method to maintain stability in tuned amplifiers.* **[Nov./Dec.-2006, 6 Marks]**

Ans. : Refer section 3.10.

Q.41 *Define class C amplifier. Sketch a tuned class C amplifier with an LC tank circuit as load. Derive its efficiency.* **[Nov./Dec.-2006, 10 Marks]**

Ans. : Refer section 3.9.

Q.42 *A class C amplifier has a base bias voltage of – 5 V and V_{CC} = 30 V. It is determined that a peak input voltage of 9.8 V at 1 MHz is required to drive the transistor to its saturation current of 1.8 A.*

1) Find the conduction angle 2) Find the output power at 1 MHz

3) Find the efficiency. **[Nov./Dec.-2006, 6 Marks]**

Ans. : 1)

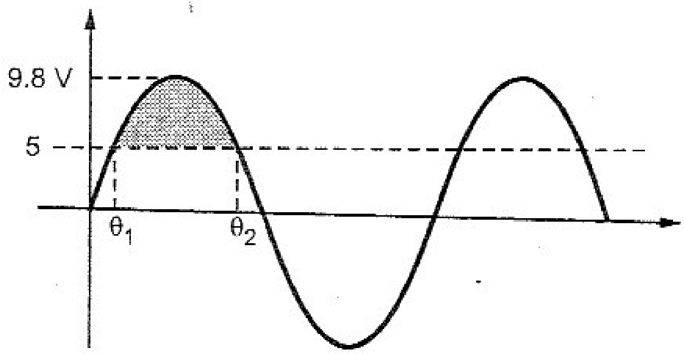

Fig. 3.46

$$\theta_1 = \sin^{-1}\frac{5}{9.8} = 30.67°$$

$$\theta_2 = 180 - \theta_1 = 149.33°$$

$\therefore$ Conduction angle $\theta = \theta_2 - \theta_1$ = **118.66°**

$$I_{dc} = \frac{1}{2\pi}\int_{\theta}^{\pi-\theta} I_m \sin\theta \, d\theta = \frac{I_m}{2\pi}(-\cos\theta)_{\theta_1}^{\theta_2}$$

$$= \frac{1.8}{2\pi} \times [0.86 + 0.86] = 0.4927 \text{ A}$$

$$P_{dc} = V_{CC} \times I_{dc} = 30 \times 0.4927$$

$$= \mathbf{14.78 \ W}$$

$$R_L = \frac{V_{CC}}{I_{sat}} = \frac{30}{1.8} = 16.67 \ \Omega$$

$$I_{rms} = \sqrt{\frac{1}{2\pi}\int_{\theta_1}^{\theta_2} I_m^2 \sin^2\theta \, d\theta}$$

$$= I_m \sqrt{\frac{1}{2\pi}\left[\frac{1}{2}\left(\theta - \frac{1}{2}\sin 2\theta\right)\right]_{\theta_1}^{\theta_2}}$$

$$= I_m\sqrt{\frac{1}{4\pi}\{[2.606-(-0.438)]-[0.535-(0.438)]\}}$$

$$= I_m\sqrt{\frac{1}{4\pi}[3.044-0.097]} = 1.8 \times \sqrt{0.2345}$$

$$= 0.8716 \text{ A}$$

$$P_{ac} = I_{rms}^2 \times R_L = 0.8716^2 \times 16.67$$

$$= \mathbf{12.6638 \ W}$$

$$\text{Efficiency} = \frac{P_{ac}}{P_{dc}} = \frac{12.6638}{14.78} = 0.8568$$

$$= \mathbf{85.68 \ \%}$$

$$P_D = P_{dc} - P_{ac} = 14.78 - 12.6638 = 2.1162 \text{ W}$$

Q.43 *Brief the relation between bandwidth and Q factor.* **[May/June-2007, 2 Marks]**

Ans. : Refer section 3.1.2.

Q.44 *A parallel resonant circuit has an inductance if 150 μH and a capacitance of 100 pF. Find the resonant frequency.* **[May/June-2007, 2 Marks]**

Ans. : **Given :** L = 150 μH and C = 100 pF

$$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{150\times10^{-6}\times100\times10^{-12}}}$$

$$= \mathbf{1299.494 \ kHz}$$

Q.45 *Discuss the working of single tuned amplifier.* **[May/June-2007, 16 Marks]**

Ans. : Refer section 3.2.

Q.46 *Explain class 'C' tuned amplifier and derive its efficiency.* **[May/June-2007, 16 Marks]**

Ans. : Refer section 3.9.

Q.47 *Mention two applications of tuned amplifiers.* **[Nov./Dec.-2007, 2 Marks]**

Ans. : Refer section 3.12.

Q.48 *What are the differences between single tuned and synchronously tuned amplifiers ?* **[Nov./Dec.-2007, 2 Marks]**

Ans. :

Sr. No.	Single tuned amplifier	Synchronously tuned amplifier
1.	It contains only one tuned circuit.	Several identical stages of tuned amplifier can connected in cascade and tuned to the same frequency.
2.	Bandwidth = BW	Bandwidth = $BW\sqrt{2^{1/n}-1}$ where n = Number of identical stages.

Q.49 *Draw the circuit diagram of a single tuned amplifier and obtain expression for its gain.* **[Nov./Dec.-2007, 16 Marks]**

Ans. : Refer section 3.2.

Q.50 *What is the need for neutralization in tuned amplifiers ?* **[Nov./Dec.-2007, 4 Marks]**

Ans. : Refer section 3.10.

Q.51 *Where is the Q point placed in a class C type amplifier ? What are its applications ?* **[May/June-2008, 2 Marks]**

Ans. : Refer section 3.9.

Q.52 *What is neutralization ?* **[May/June-2008, 2 Marks]**

Ans. : Refer section 3.10.

Q.53 *Draw the circuit of class C tuned amplifier and explain its operation with relevant waveforms.* **[May/June-2008, 8 Marks]**

Ans. : Refer section 3.9.

Q.54 *Discuss the Hazeltine method to neutralization with circuit.* **[May/June-2008, 8 Marks]**

Ans. : Refer section 3.10.

Q.55 *Discuss instability of tuned amplifier.* **[May/June-2008, 4 Marks]**

Ans. : Refer section 3.10.

Q.56 *Mention applications of tuned amplifiers.* **[Nov./Dec.-2008, 2 Marks]**

Ans. : Refer section 3.12.

Q.57 *What is the need for neutralization in tuned amplifiers ?* **[Nov./Dec.-2008, 2 Marks]**

Ans. : Refer section 3.10.

Q.58 *Define quality factor. Obtain the quality factor for a parallel resonant circuit.* **[Nov./Dec.-2008, 12 Marks]**

Ans. : Refer section 3.1.1.

Q.59 *A parallel resonant circuit has a capacitor of 100 pF and an inductor of 100 micro H. The inductor has a resistance of 5 ohms. Find the value of frequency at which the circuit resonates and the circuit impedance at resonance.* **[Nov./Dec.-2008, 4 Marks]**

Ans. :

$$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{100\times 10^{-6}\times 100\times 10^{-12}}}$$

$$= 1.59155 \text{ MHz}$$