INTEGRATED TECHNICAL EDUCATION CLUSTER
AT ALAMEERIA

J-601-1448
Electronic Principals

Lecture #9
Tuned Amplifiers

Instructor:

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Agenda

- Class C vs. Tuned Amplifier
- Basic Operation
- Tuned Operation
- Sharpness of Resonance
- Clamper Bias

CLASS C VS. TUNED AMPLIFIER

Introduction

- Class C amplifiers are biased so that conduction occurs for much less than 180°.
- Class C amplifiers are more efficient than either class A or push-pull class B and class AB, which means that more output power can be obtained from class C operation.
- The output amplitude is a nonlinear function of the input, so class C amplifiers are not used for linear amplification.
- They are generally used in radio frequency (RF) applications, including circuits, such as
    - oscillators, that have a constant output amplitude
    - modulators, where a high-frequency signal is controlled by a low-frequency signal.

- Therefore, <u>Class C amplifiers are also called Tuned Amplifiers.</u>

- An amplifier which amplifies a specific frequency (or a narrow band of frequencies) is called a *tuned voltage amplifier*.
- It has two purposes:
    - Selection of a desired radio frequency signal.
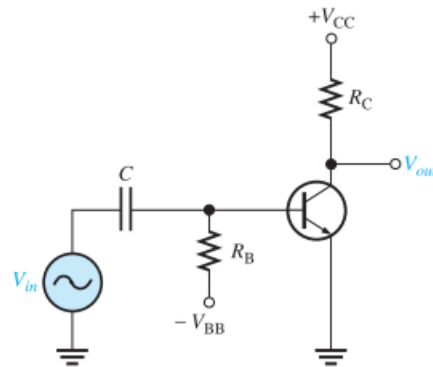   - Amplification of the selected signal to a suitable voltage level.
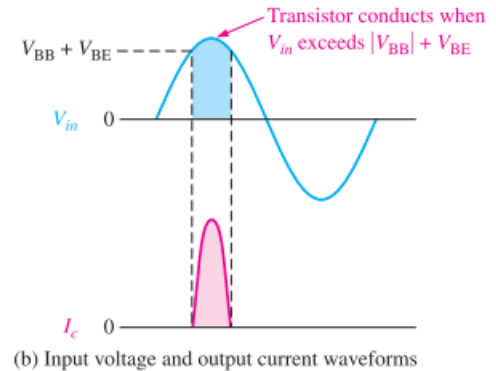
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BASIC OPERATION
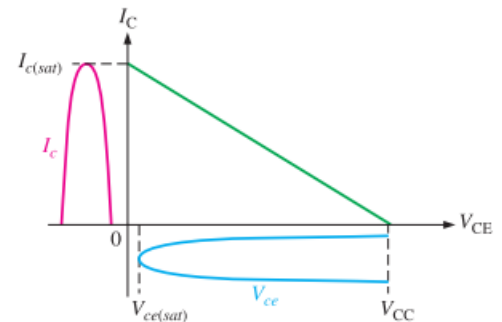
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Class C operation
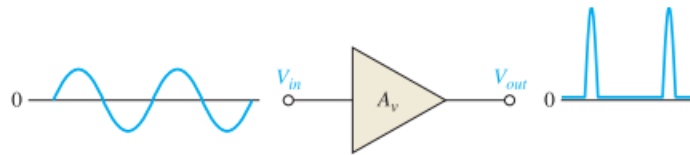
- It is biased below cutoff with the negative V_{BB} supply.
- A class C amplifier is normally operated with a resonant circuit load, so the resistive load is used only for the purpose of illustrating the concept.
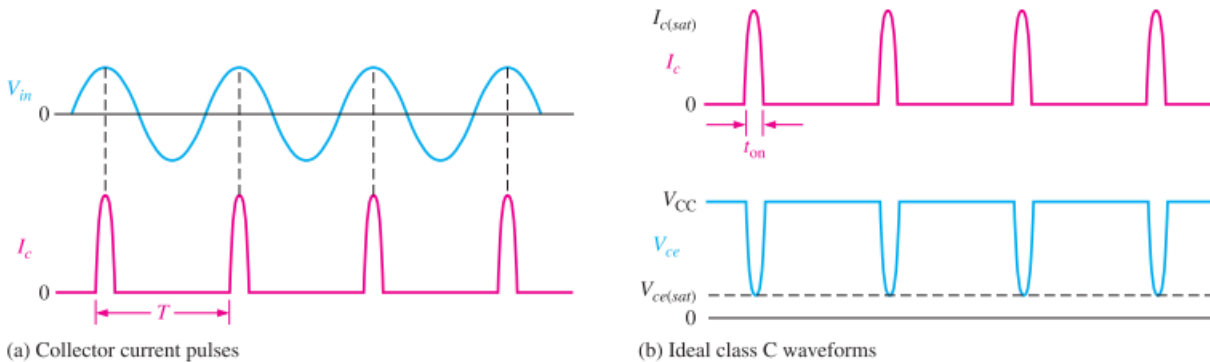

(a) Basic class C amplifier circuit

(b) Input voltage and output current waveforms

Transistor conducts when V_{in} exceeds $|V_{BB}| + V_{BE}$

(c) Load line operation

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Power Dissipation

(a) Collector current pulses

(b) Ideal class C waveforms

- The power dissipation of the transistor in a class C amplifier is low because it is on for only a small percentage of the input cycle.
- To avoid complex mathematics, we will assume ideal pulse approximations.
- Using this simplification, if the output swings over the entire load, the maximum current amplitude is $I_c(sat)$ and the minimum voltage amplitude is $V_{ce}(sat)$ during the time the transistor is on.

- The power dissipation during the on time is $P_{D(on)} = I_{c(sat)}V_{ce(sat)}$

- The transistor is on for a short time, t_{on}, and off for the rest of the input cycle.
- The power dissipation averaged over the entire cycle is

$$P_{D(avg)} = \left(\frac{t_{on}}{T}\right)P_{D(on)} = \left(\frac{t_{on}}{T}\right)I_{c(sat)}V_{ce(sat)}$$
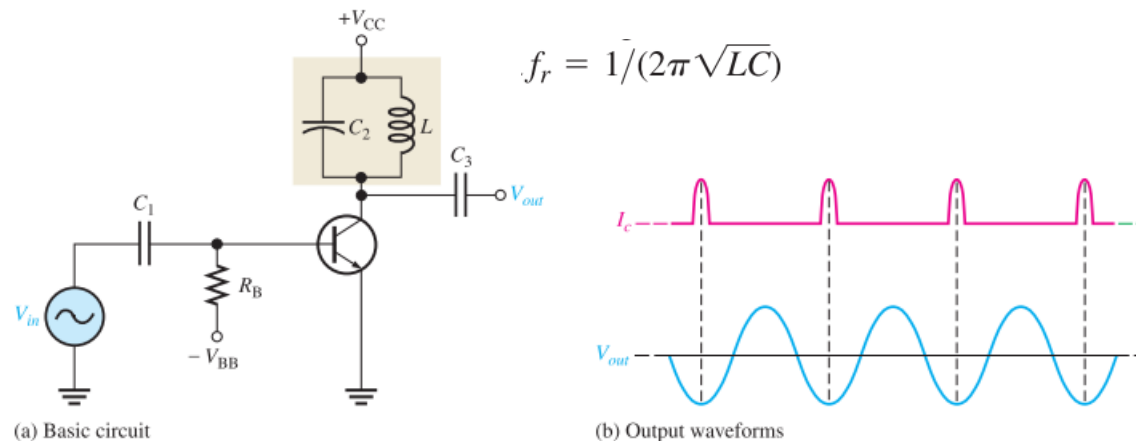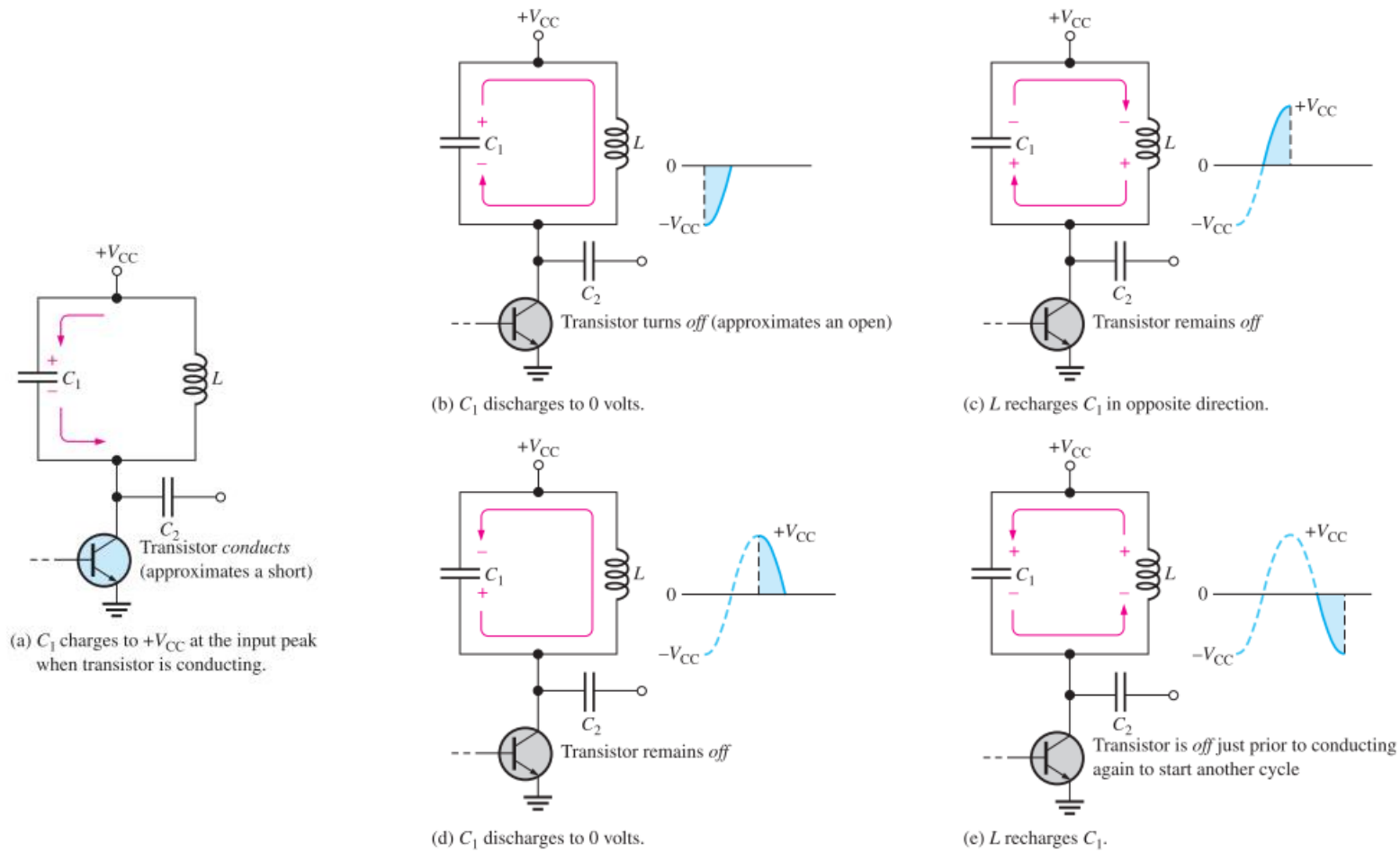
Check EXAMPLE 7–7!

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TUNED OPERATION

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Usage of Parallel Resonance Circuit

- Because the collector voltage (output) is not a replica of the input, the resistively loaded class C amplifier alone is of no value in linear applications.
- It is therefore necessary to use a class C amplifier with a parallel resonant circuit (tank).
- The short pulse of collector current on each cycle of the input initiates and sustains the oscillation of the tank circuit so that an output sinusoidal voltage is produced.
- The tank circuit has high impedance only near the resonant frequency, so the gain is large only at this frequency.

$$f_r = 1/(2\pi\sqrt{LC})$$

(a) Basic circuit

(b) Output waveforms

▲ FIGURE 7–24

Tuned class C amplifier.

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Resonant Circuit Action

+V_{CC}

C_1 L

C_2
Transistor *conducts*
(approximates a short)

(a) C_1 charges to +V_{CC} at the input peak when transistor is conducting.

+V_{CC}

C_1 L

0

−V_{CC}

C_2
Transistor turns *off* (approximates an open)

(b) C_1 discharges to 0 volts.

+V_{CC}

C_1 L

0

+V_{CC}

−V_{CC}

C_2
Transistor remains *off*

(c) L recharges C_1 in opposite direction.

+V_{CC}

C_1 L

0

+V_{CC}

−V_{CC}

C_2
Transistor remains *off*

(d) C_1 discharges to 0 volts.

+V_{CC}

C_1 L

0

+V_{CC}

−V_{CC}

C_2
Transistor is *off* just prior to conducting again to start another cycle

(e) L recharges C_1.

▲ FIGURE 7–25

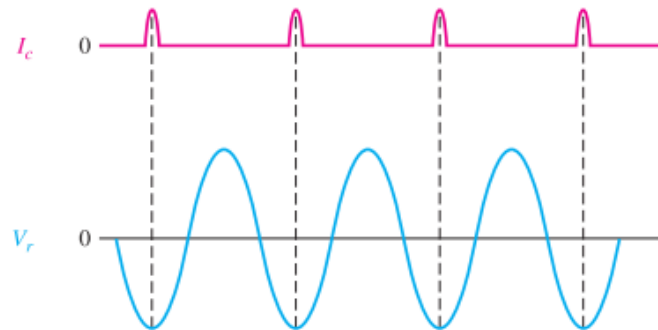Resonant circuit action.

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SHARPNESS OF RESONANCE

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# Resonant Circuit Action..

▶ **FIGURE 7–26**

Tank circuit oscillations. V_r is the voltage across the tank circuit.

V_r 0
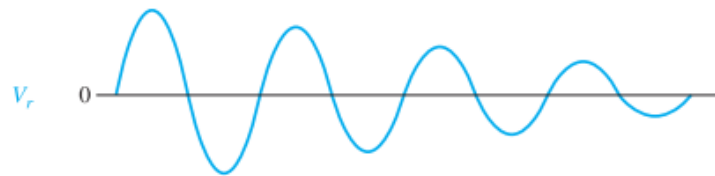
(a) An oscillation will gradually die out (decay) due to energy loss. The rate of decay depends on the efficiency of the tank circuit.

I_c 0

V_r 0

(b) Oscillation at the fundamental frequency can be sustained by short pulses of collector current.

I_c 0

V_r 0

frequency multiplier (x2)
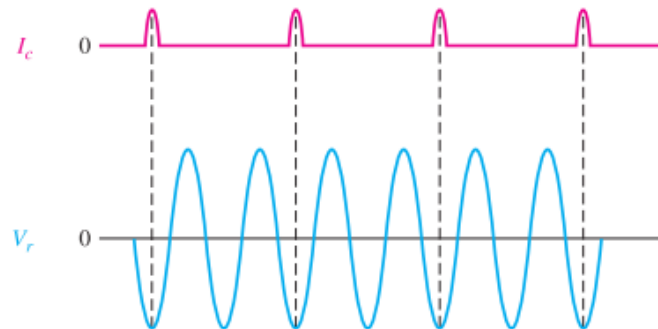
(c) Oscillation at the second harmonic frequency

Resonance Curve Sharpness

- The resonance curve is required to be as sharp as possible in order to provide a high selectivity.
- A sharp resonance curve means that the impedance falls off rapidly as the frequency is varied above and below the resonant frequency.

$$\text{Sharpness of resonance} = \frac{\text{Bandwidth}}{\text{Resonant frequency}} = \frac{BW}{f_o} = \frac{f_2 - f_1}{f_o} = \frac{1}{Q_o}$$
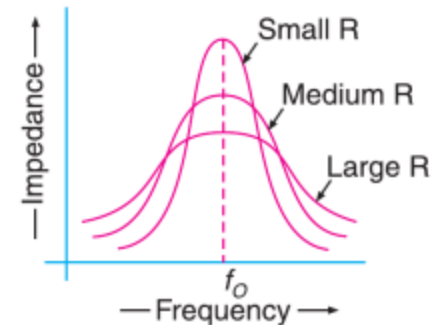
the Q-factor, $\quad Q_o = \dfrac{X_L}{R} = \dfrac{\omega_o \cdot L}{R} = \dfrac{2\pi f_o \cdot L}{R}$

L = Value of circuit inductance, and
R = Value of circuit resistance or coil resistance.
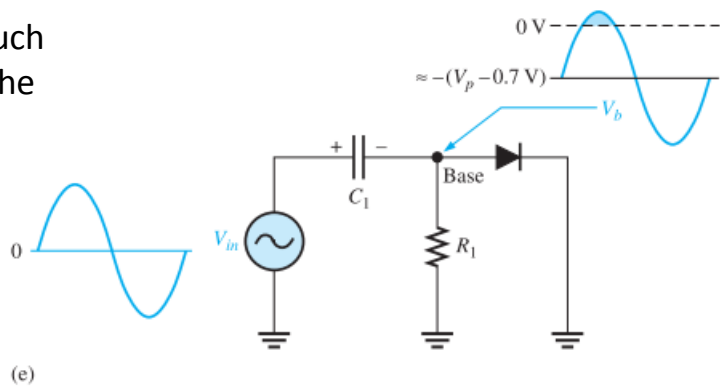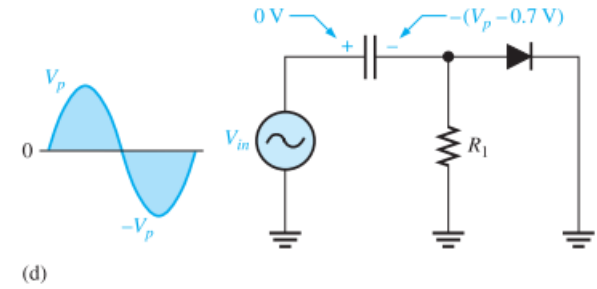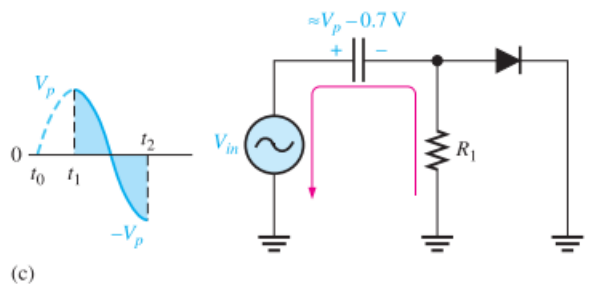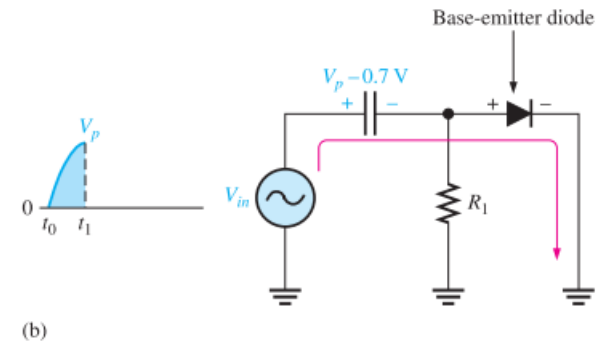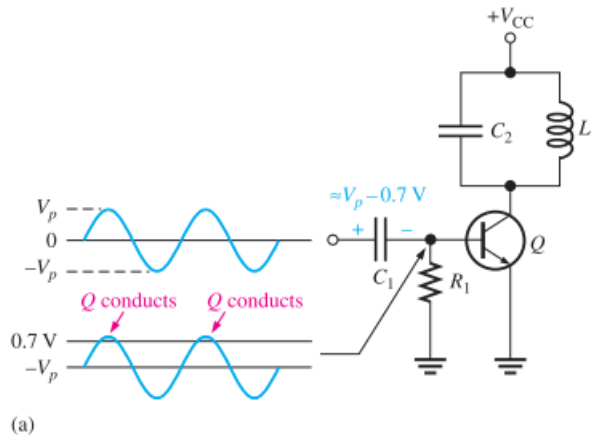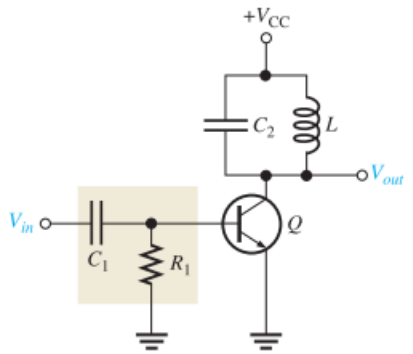
$$BW = \frac{f_o}{Q_o}$$

$$f_o = BW \times Q_o$$

Fig. 28.5. Effect of coil resistance (*R*) on the sharpness of resonance curves.

- A higher value of quality factor (Q_o) provides a higher selectivity but a smaller bandwidth and vice versa.

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CLAMPER BIAS

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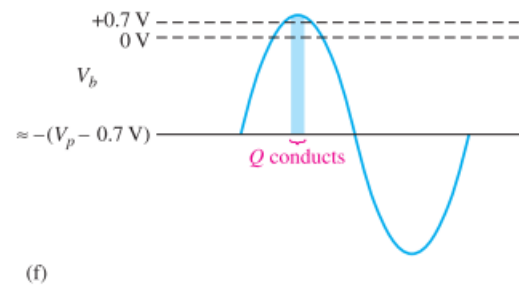
Clamper Bias

For good clamping action, the R_1C_1 time constant of the clamping circuit must be much greater than the period of the input signal.

▲ FIGURE 7–28

Clamper bias action.

- For more details, refer to:
  - Chapter 7, section 7-3,T. Floyd, **Electronic Devices**,9th edition.
  - Chapter 28, section 28.5, Sedha, **Text Book of Applied Electronics**, 2003.
- The lecture is available online at:
  - https://speakerdeck.com/ahmad_elbanna
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