



BENHA UNIVERSITY
FACULTY OF ENGINEERING AT SHOUBRA

ECE-312
Electronic Circuits (A)

Lecture # 13
Tuned Amplifiers

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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

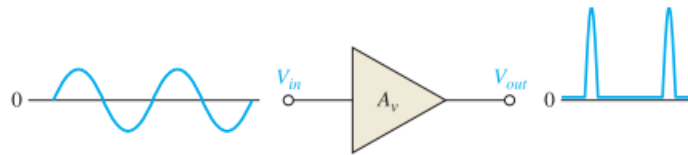
- Class C amplifiers are biased so that conduction occurs for much less than 180° .
- Class C amplifiers are more efficient than either class A or push-pull class B and class AB, which means that more output power can be obtained from class C operation.
- The output amplitude is a nonlinear function 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, Class C amplifiers are also called Tuned Amplifiers.
- 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.

BASIC OPERATION

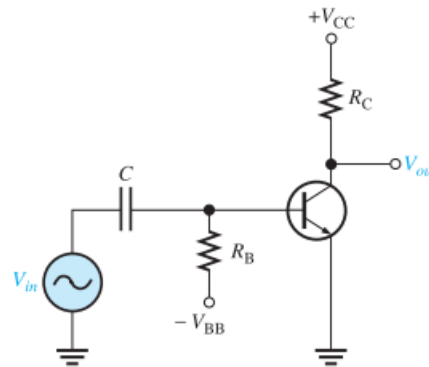


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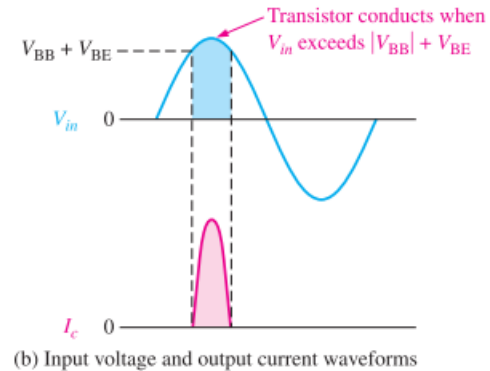
Class C operation



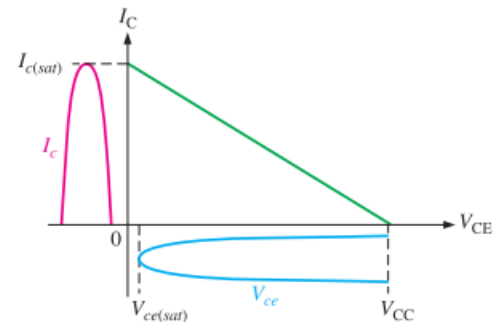
- It is biased below cutoff with the negative V_{BB} supply.
- A class C amplifier is normally operated with a resonant circuit load, so the resistive load is used only for the purpose of illustrating the concept.



(a) Basic class C amplifier circuit

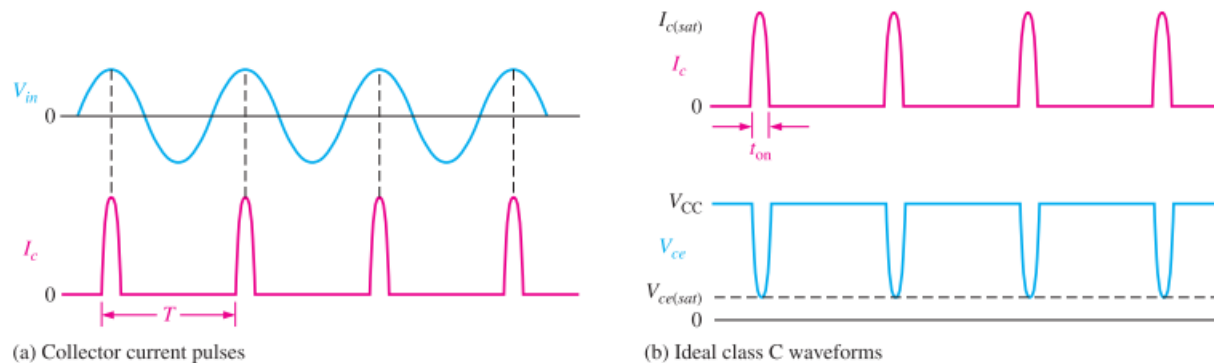


(b) Input voltage and output current waveforms



(c) Load line operation

Power Dissipation



- 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!

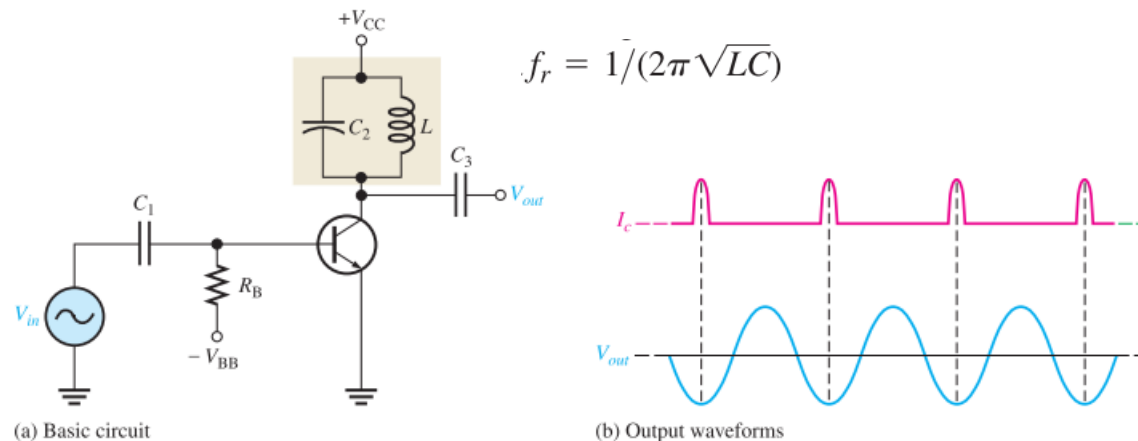


TUNED OPERATION



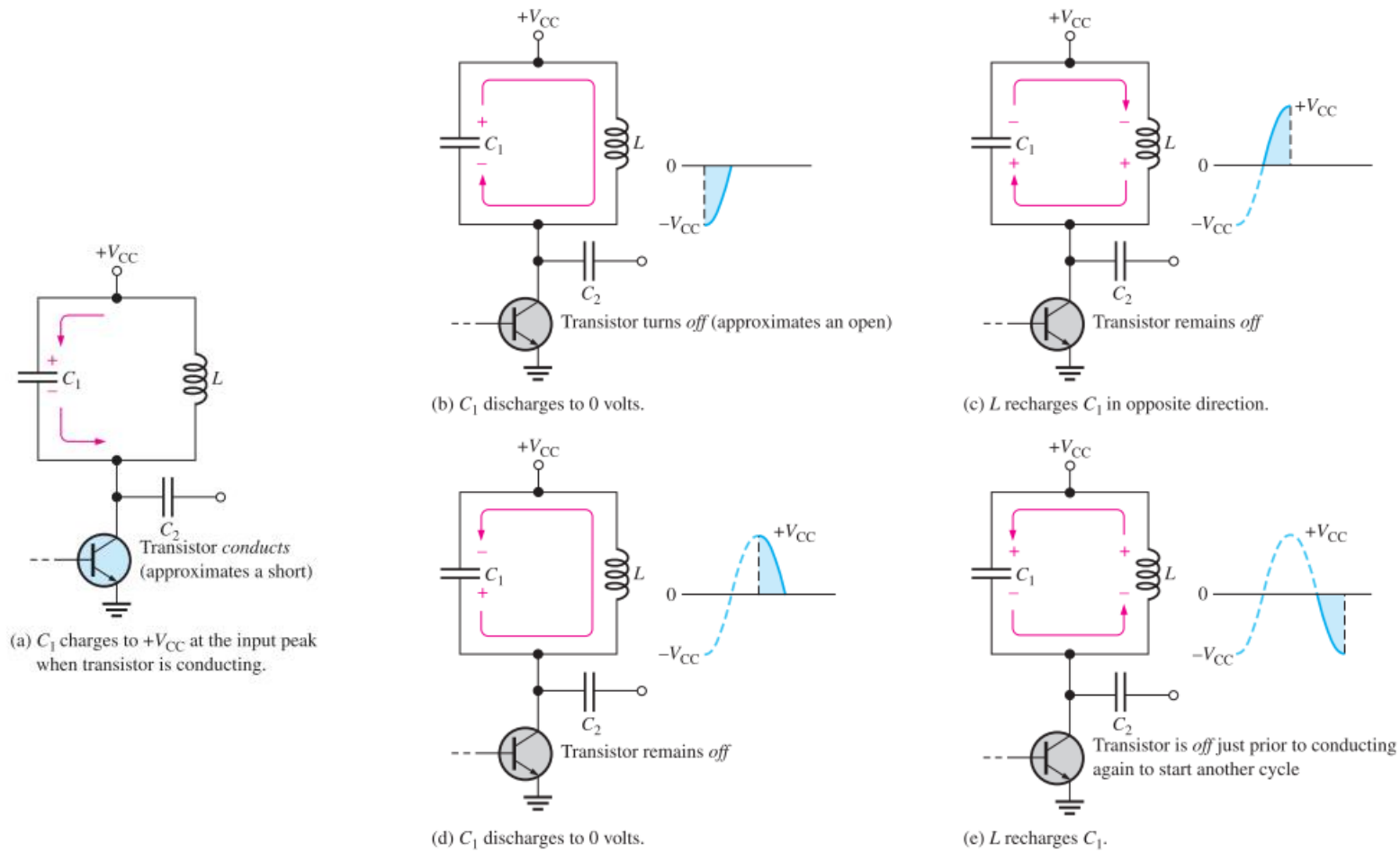
Usage of Parallel Resonance Circuit

- 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.



▲ FIGURE 7-24
Tuned class C amplifier.

Resonant Circuit Action



▲ FIGURE 7-25

Resonant circuit action.



Resonant Circuit Action..

► **FIGURE 7-26**

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

Maximum Output Power

voltage developed across the tank circuit has a peak-to-peak value of $\cdot 2V_{CC}$

$$P_{out} = \frac{V_{rms}^2}{R_c} = \frac{(0.707V_{CC})^2}{R_c}$$

$$P_{out} = \frac{0.5V_{CC}^2}{R_c}$$

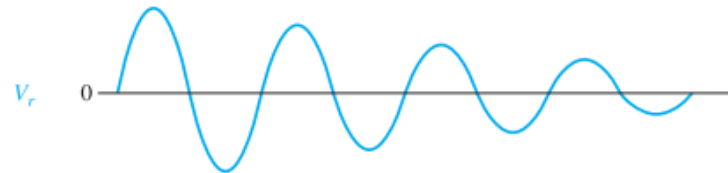
R_c is the equivalent parallel resistance of the collector tank circuit

The total power that must be supplied to the amplifier is

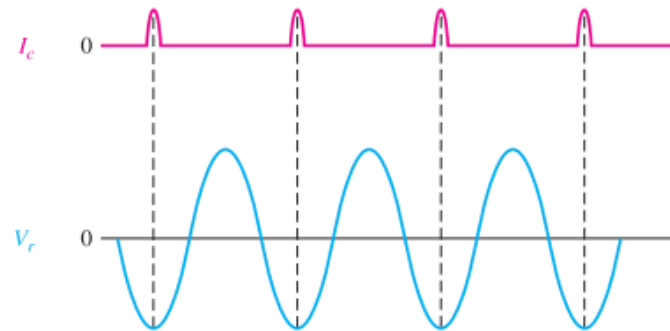
$$P_T = P_{out} + P_{D(avg)}$$

$$\eta = \frac{P_{out}}{P_{out} + P_{D(avg)}}$$

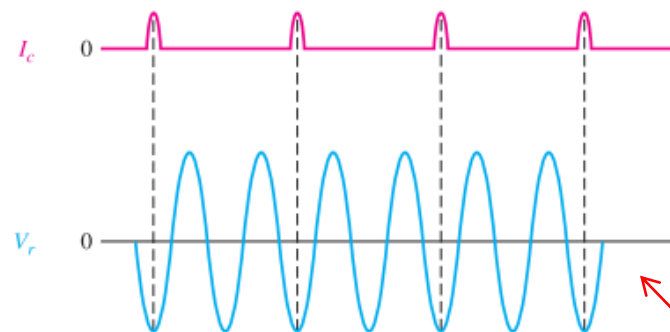
When $P_{out} \gg P_{D(avg)}$, the class C efficiency closely approaches 1 (100 percent).



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



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



(c) Oscillation at the second harmonic frequency

frequency multiplier (x2)



SHARPNESS OF RESONANCE



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.

$$\text{Sharpness of resonance} = \frac{\text{Bandwidth}}{\text{Resonant frequency}} = \frac{BW}{f_o} = \frac{f_2 - f_1}{f_o} = \frac{1}{Q_o}$$

$$\text{the } Q\text{-factor; } Q_o = \frac{X_L}{R} = \frac{\omega_o \cdot L}{R} = \frac{2\pi f_o \cdot L}{R}$$

L = Value of circuit inductance, and

R = Value of circuit resistance or coil resistance.

$$BW = \frac{f_o}{Q_o}$$

$$f_o = BW \times Q_o$$

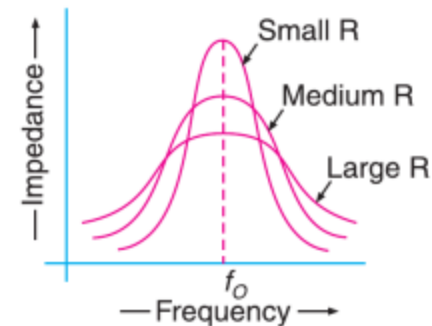


Fig. 28.5. Effect of coil resistance (R) on the sharpness of resonance curves.

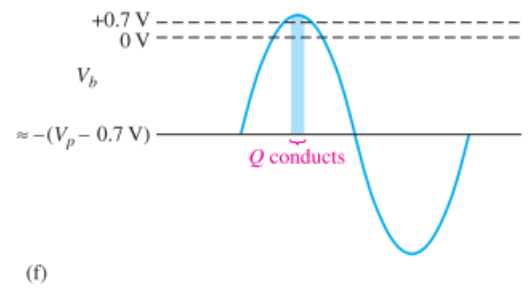
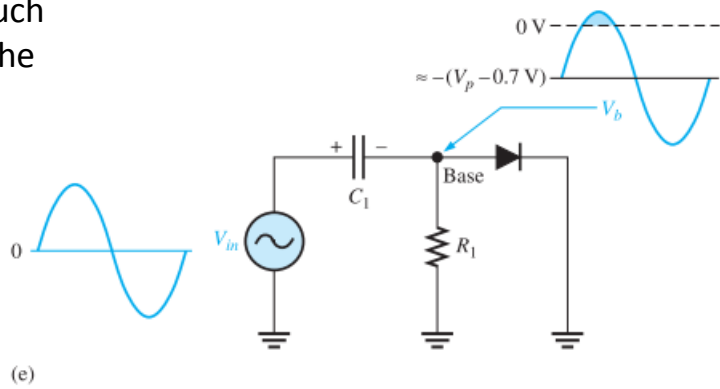
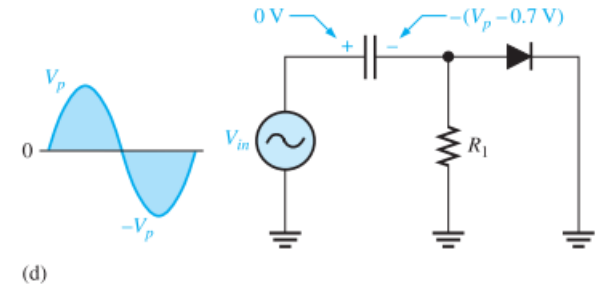
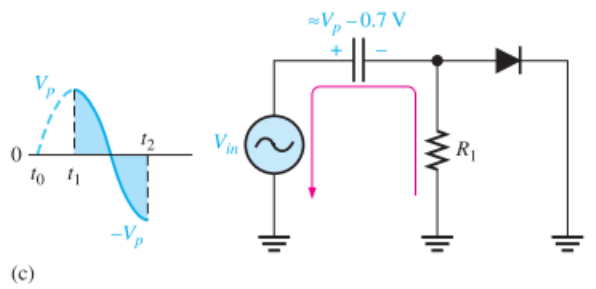
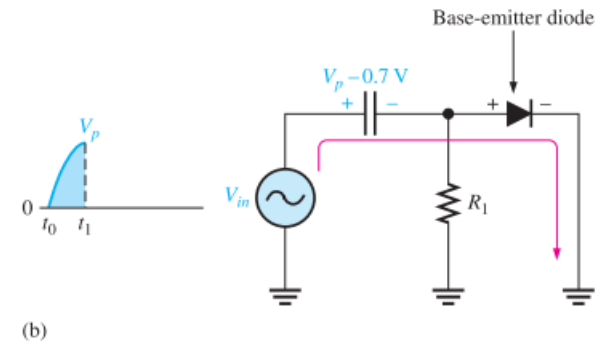
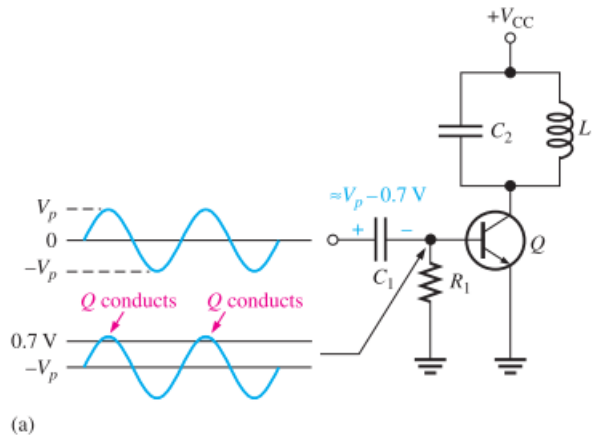
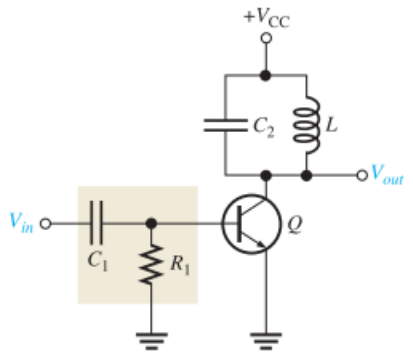
- A higher value of quality factor (Q_o) provides a higher selectivity but a smaller bandwidth and vice versa.

CLAMPER BIAS





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:
 - <http://bu.edu.eg/staff/ahmad.elbanna-courses/11966>
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