ECE 312
Electronic Circuits (A)

Lec. 16: Tuned Amplifiers

Instructor

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Ref: Electronic Devices 9th edition, Chapter 7, Thomas Floyd

Agenda

- Introduction
- Class C basic Operation
- Tuned Operation
- Class C power efficiency

Introduction

- Class C amplifiers are biased so that conduction occurs for much less than 180^o.
- 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.

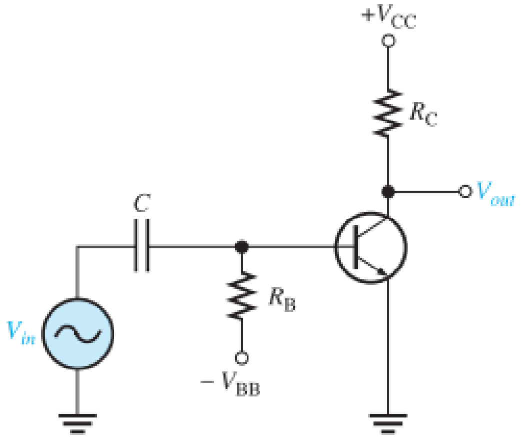
- They are generally used in radio frequency (RF) applications, including circuits, such as
  - oscillators, that have a constant output amplitude
  - modulators, where a high-frequency signal is controlled by a low-frequency signal.
- Therefore, <u>Class C amplifiers are also called Tuned Amplifiers.</u>

- An amplifier which amplifies a specific frequency (or a narrow band of frequencies) is called a *tuned voltage amplifier*.

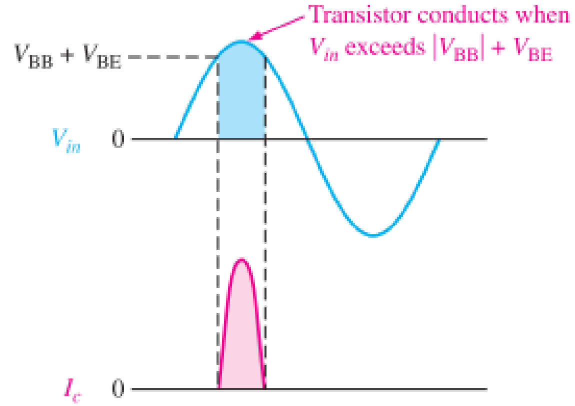
- It has two purposes:
  - Selection of a desired radio frequency signal.
  - Amplification of the selected signal to a suitable voltage level.

Class C operation

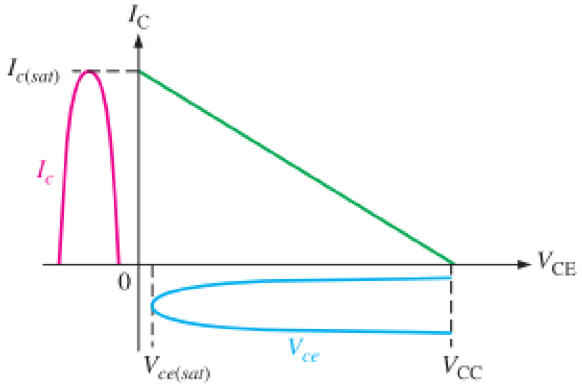
- It is biased below cutoff with the negative V_{BB} supply.
- A class C amplifier is normally operated with a resonant circuit load, so the resistive load is used only for the purpose of illustrating the concept.



(a) Basic class C amplifier circuit



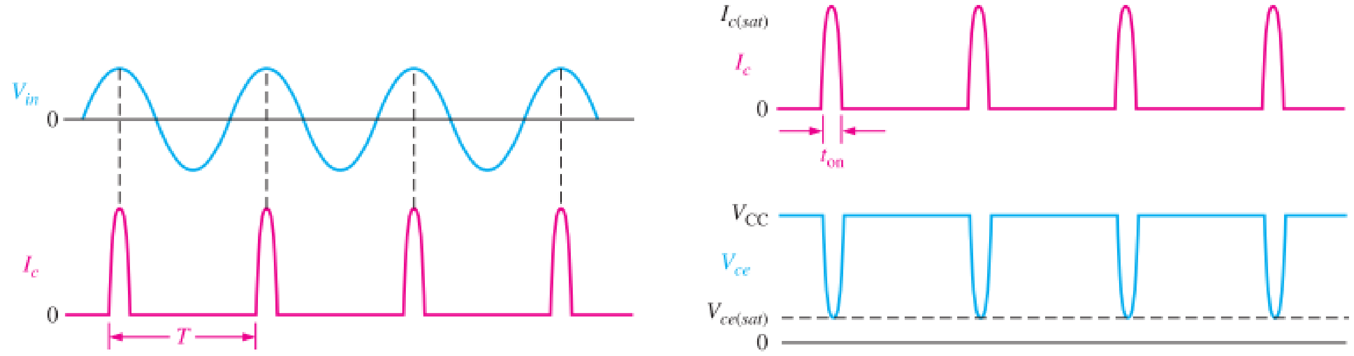
(b) Input voltage and output current waveforms



(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.



(a) Collector current pulses

(b) Ideal class C waveforms

- The power dissipation during the on time is

$$P_{D(on)} = I_{c(sat)} V_{ce(sat)}$$

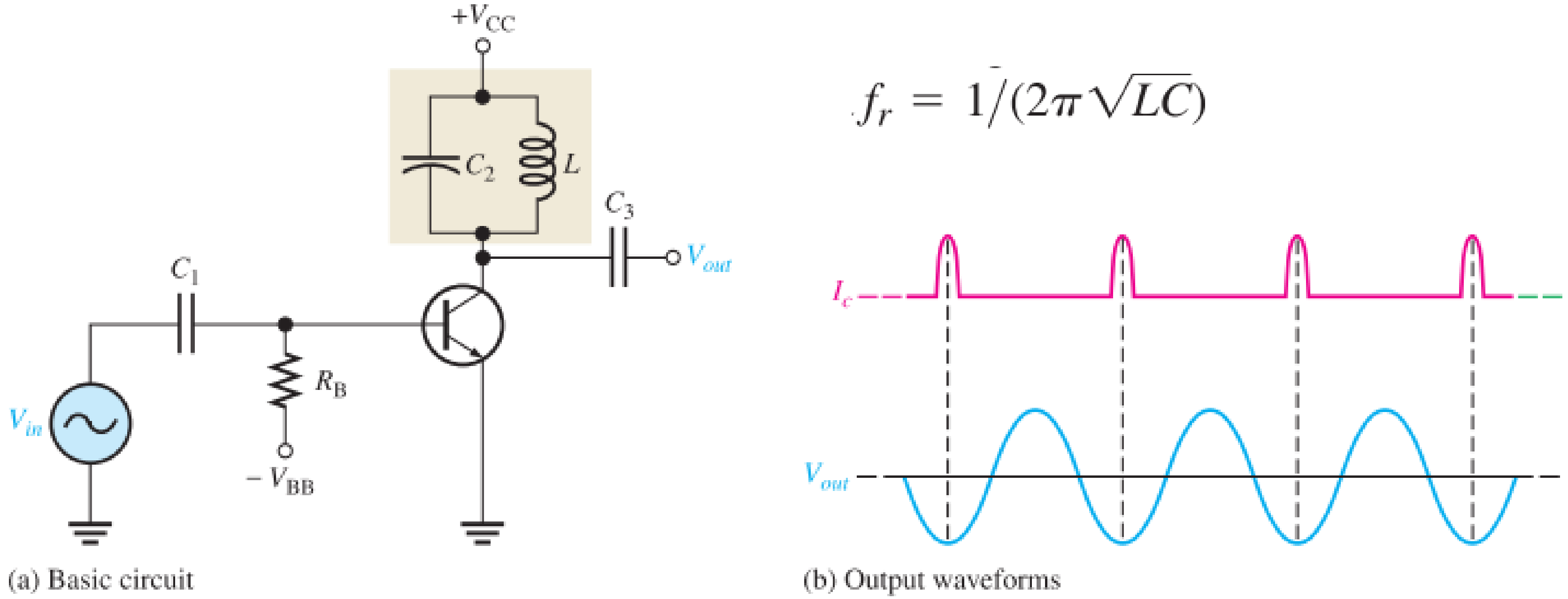
- The transistor is on for a short time, t_{on}, and off for the rest of the input cycle.
- The power dissipation averaged over the entire cycle is

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

Check EXAMPLE 7–7!

Tuned Operation

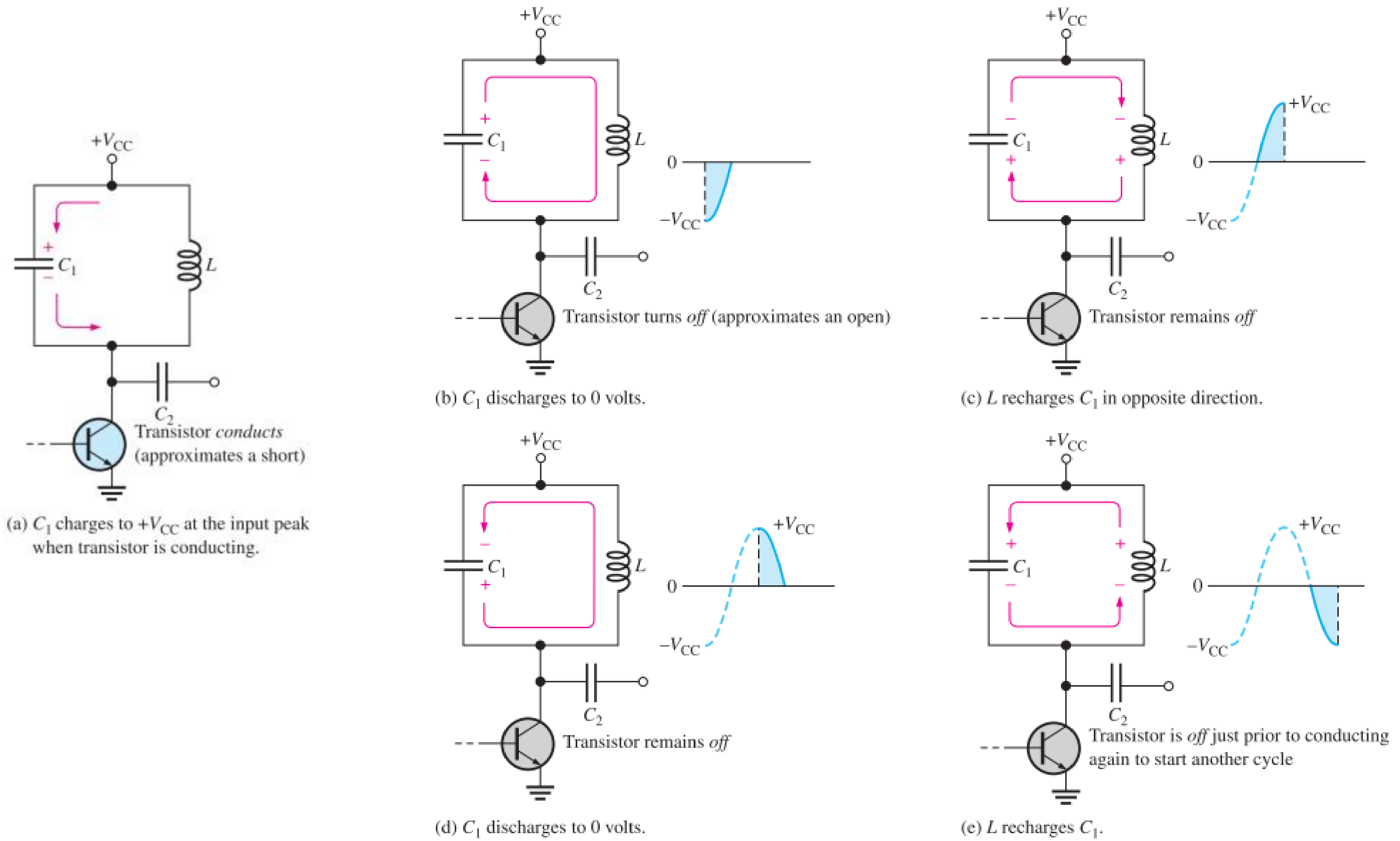
- Because the collector voltage (output) is not a replica of the input, the resistively loaded class C amplifier alone is of no value in linear applications.
- It is therefore necessary to use a class C amplifier with a parallel resonant circuit (tank).
- The short pulse of collector current on each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



▲ FIGURE 7–24

Tuned class C amplifier.

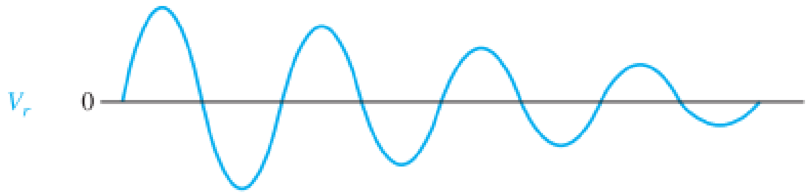
Resonant Circuit Action (1 of 2)



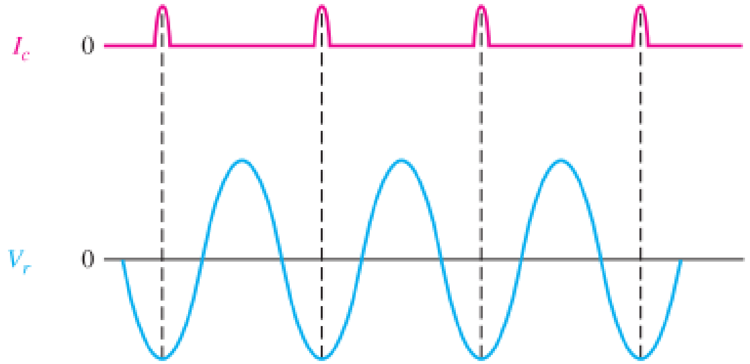
Resonant Circuit Action (2 of 2)

FIGURE 7–26

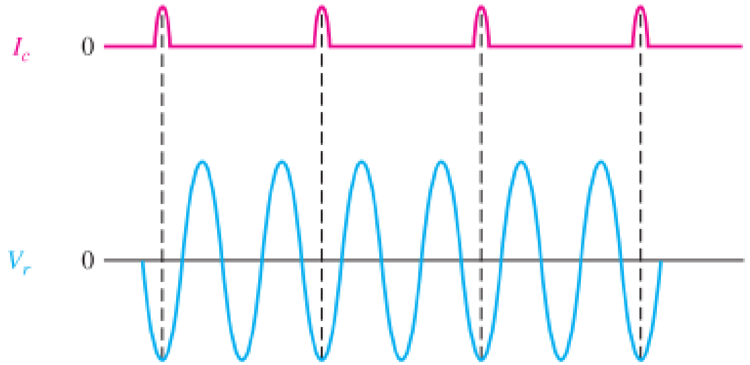
Tank circuit oscillations. V_r is the voltage across the tank circuit.



(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)

Class C power efficiency

Maximum Output Power

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

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

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

R_c is the equivalent parallel resistance of the collector tank circuit

The total power that must be supplied to the amplifier is

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

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

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


Thank You!