Class C Power Amplifier

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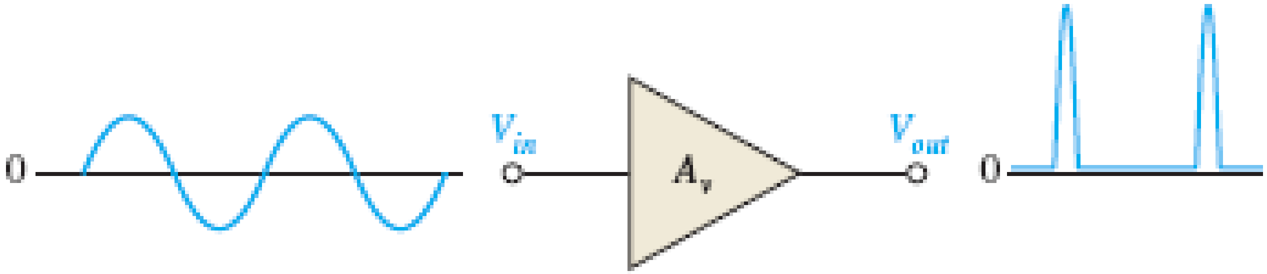
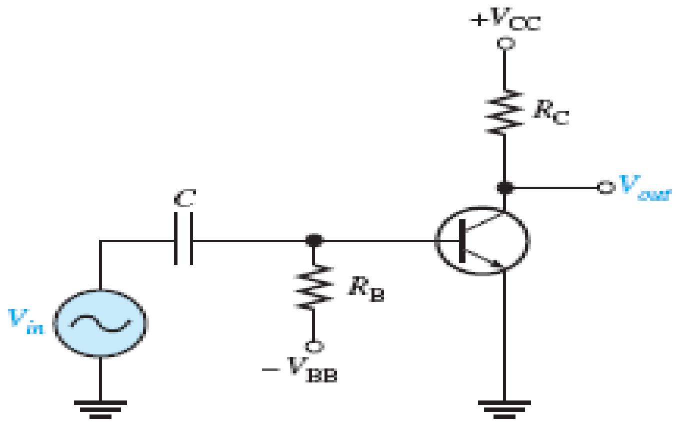
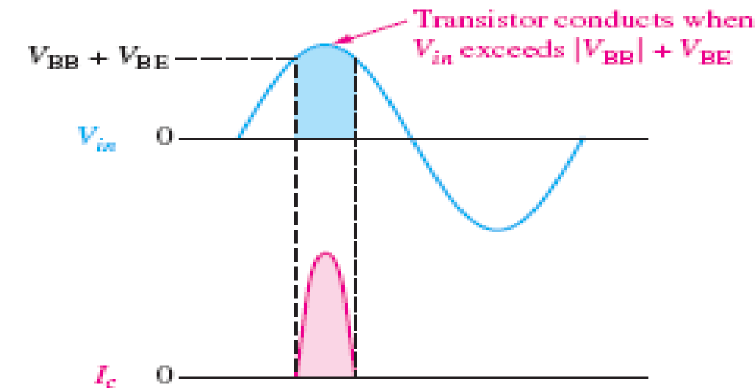
Class C amplifiers are biased so that conduction occurs for much less than 180° .

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.

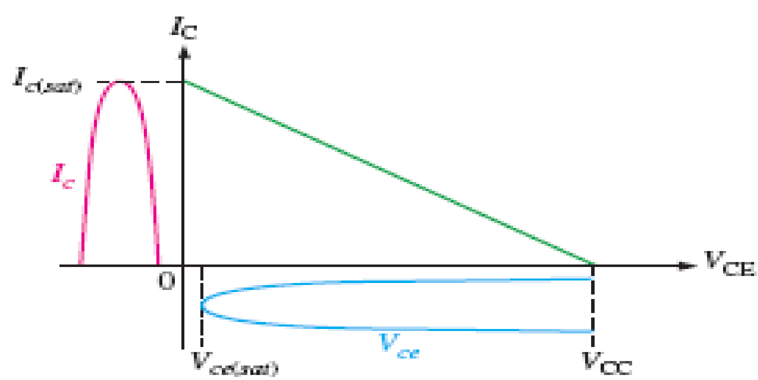




(a) Basic class C amplifier circuit



(b) Input voltage and output current waveforms



(c) Load line operation

The ac source voltage has a peak value that is slightly greater than $|V_{BB}| + V_{BE}$ so that the base voltage exceeds the barrier potential of the base-emitter junction for a short time near the positive peak of each cycle, during this short interval, the transistor is turned on.

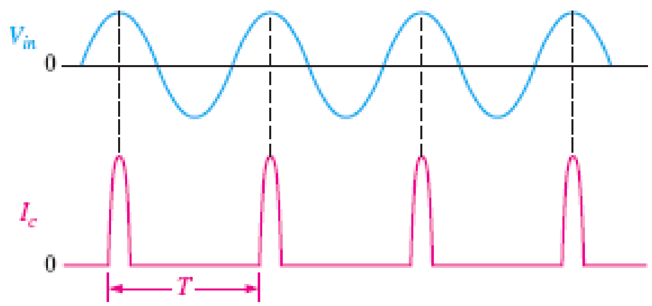
Power Dissipation

The power dissipation during the *on time is,*

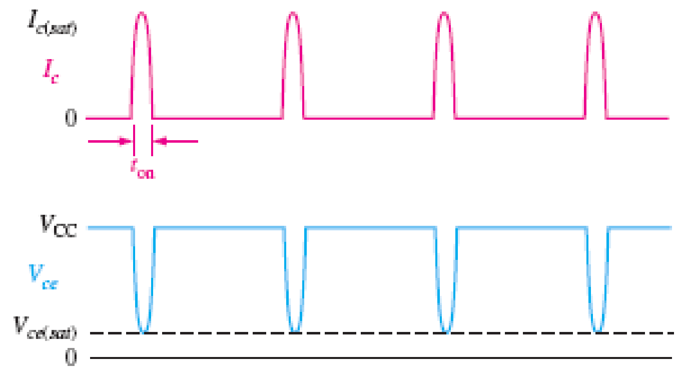
$$P_{D(on)} = I_{c(sat)}V_{ce(sat)}$$

The transistor is on for a short time, t_{on}, *and off for the rest of the input cycle. Therefore,* assuming the entire load line is used, the power dissipation averaged over the entire cycle is,

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



(a) Collector current pulses



(b) Ideal class C waveforms

Example

A class C amplifier is driven by a 200 kHz signal. The transistor is on for 1 μs, and the amplifier is operating over 100 percent of its load line. If $I_{c(sat)} = 100$ mA and $V_{ce(sat)} = 0.2$ V, what is the average power dissipation of the transistor?

The period is

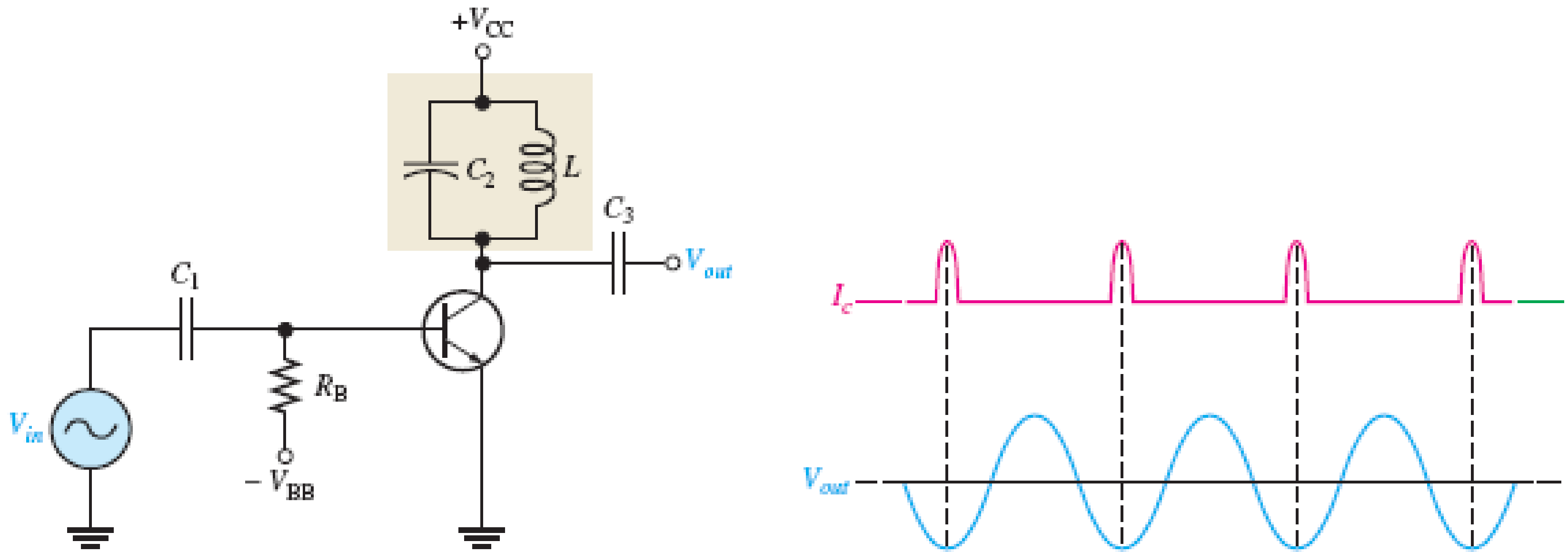
$$T = \frac{1}{200\,\text{kHz}} = 5\,\mu\text{s}$$

Therefore,

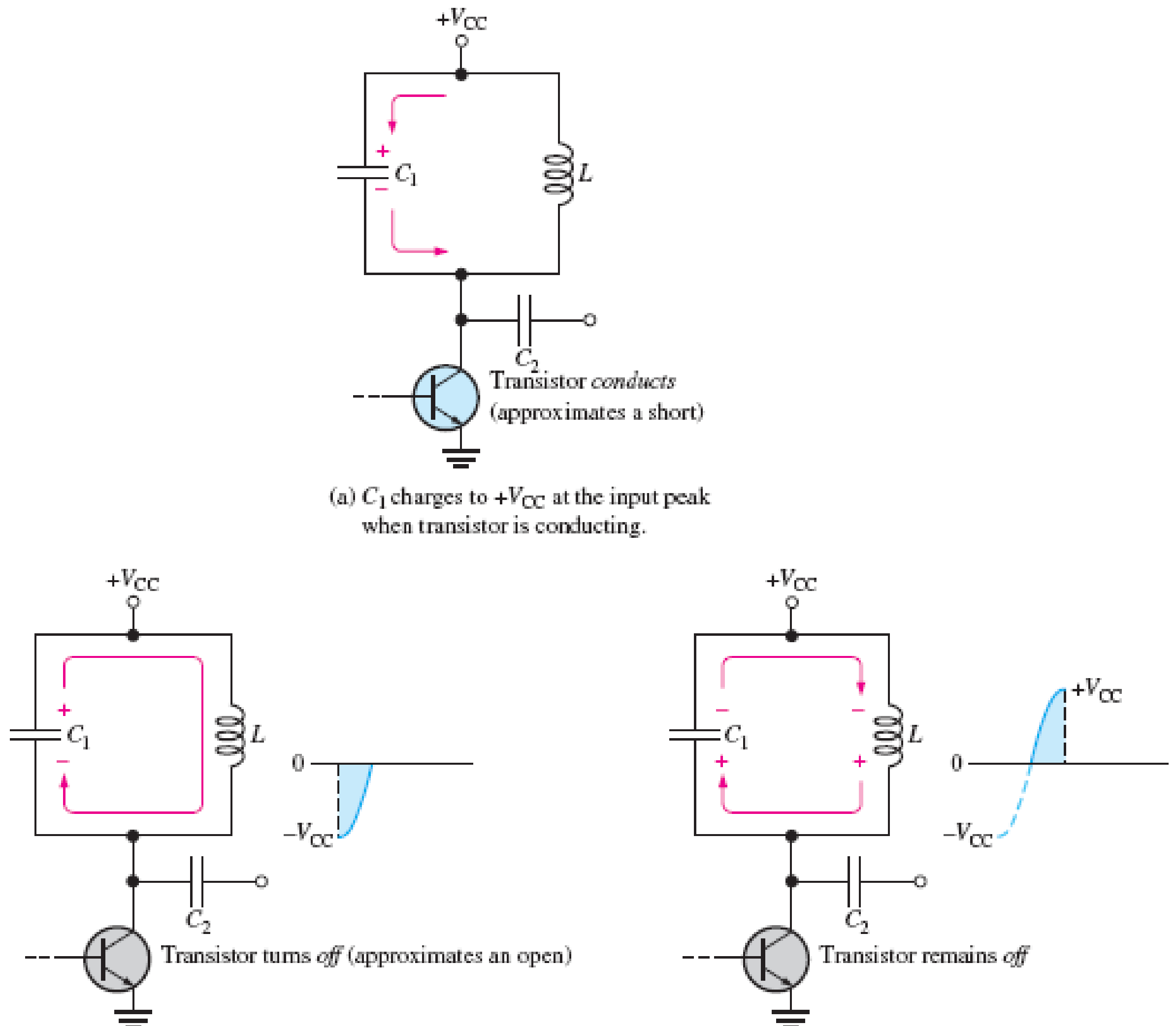
$$P_{\text{D(avg)}} = \left(\frac{t_{\text{on}}}{T}\right) I_{c(sat)} V_{ce(sat)} = (0.2)(100\text{ mA})(0.2\text{ V}) = \mathbf{4\ mW}$$

The low power dissipation of the transistor operated in class C is important because, as you will see later, it leads to a very high efficiency when it is operated as a tuned class C amplifier in which relatively high power is achieved in the resonant circuit.

Tuned Operation



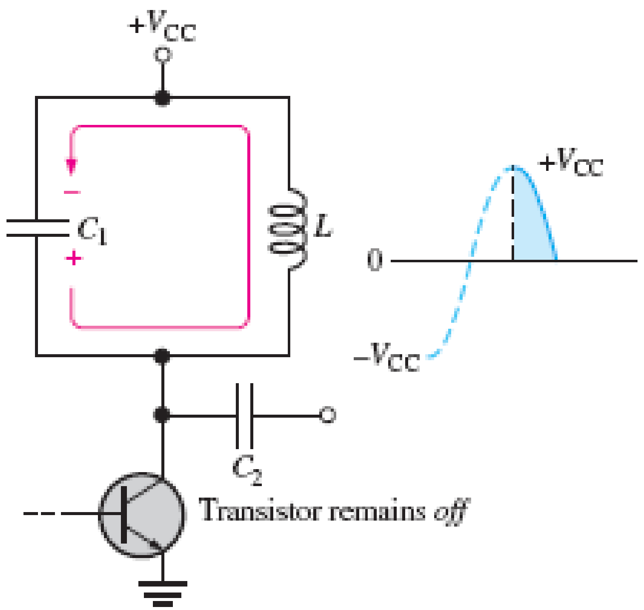
(a) Basic circuit (b) Output waveforms



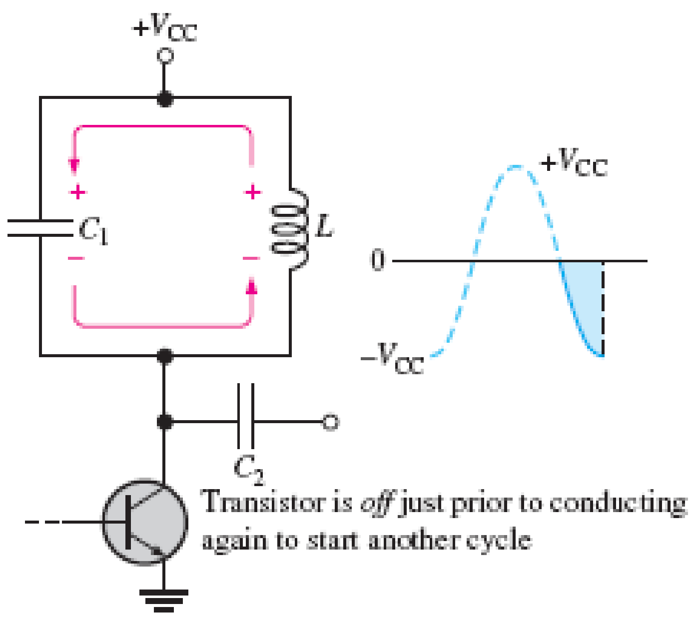
(a) C_1 charges to $+V_{CC}$ at the input peak when transistor is conducting.

(b) C_1 discharges to 0 volts.

(c) L recharges C_1 in opposite direction.



(d) C_1 discharges to 0 volts.



(e) L recharges C_1.

Maximum output Power and Efficiency

Since the voltage developed across the tank circuit has a peak-to-peak value of approximately $2V_{CC}$, the maximum output power can be expressed as

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

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

R_c is the equivalent parallel resistance of the collector tank circuit at resonance and represents the parallel combination of the coil resistance and the load resistance. It usually has a low value. The total power that must be supplied to the amplifier is

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

Therefore, the efficiency is

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

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