TRANSISTOR AMPLIFIER

An *amplifier* is an electronic device that increases the voltage, current, or power of a signal.

Classification of amplifiers

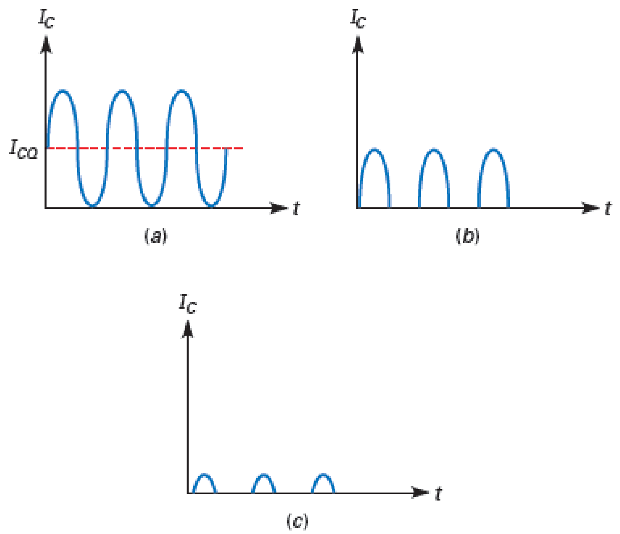


Figure 1: Collector current: (*a*) Class-A; (*b*) Class-B; (*c*) Class-C.

Classes of Operation

Class-A operation of an amplifier means that the transistor operates in the active region at all times. This implies that collector current flows for 360° of the ac cycle, as shown in Fig. 1(a). With a Class-A amplifier, the designer usually tries to locate the *Q* point somewhere near the middle of the load line. This way, the signal can swing over the maximum possible range without saturating or cutting off the transistor, which would distort the signal.

Class-B operation is different. It means that collector current flows for only half the cycle (180°), as shown in Fig. 1(b). To have this kind of operation, a designer locates the *Q* point at cutoff. Then, only the positive half-cycle of ac base voltage can produce collector current. This reduces the wasted heat in power transistors.

Class-C operation means that collector current flows for less than 180° of the ac cycle, as shown in Fig. 1(c). With Class-C operation, only part of the positive half-cycle of ac base voltage produces collector current. As a result, we get brief pulses of collector current like those of Fig. 1(c).

Types of Coupling

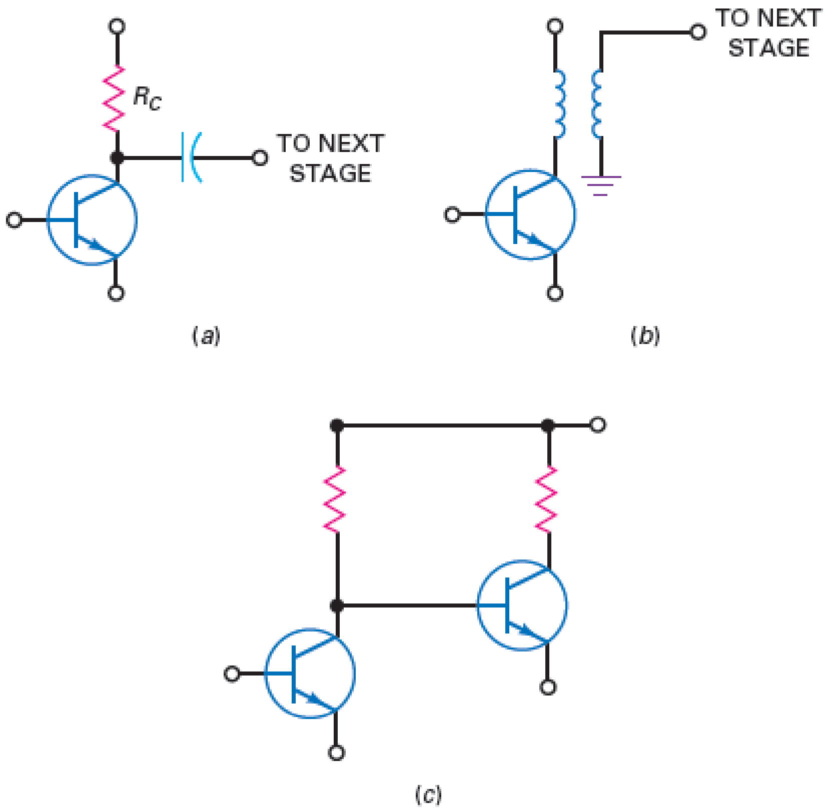


Figure 2 : Types of coupling: (*a*) capacitive; (*b*) transformer; (*c*) direct

Figure 2 (a) shows **capacitive coupling.** The coupling capacitor transmits the amplified ac voltage to the next stage.

Figure 2 (b) *illustrates* **transformer coupling.** Here, the ac voltage is coupled through a transformer to the next stage.

Capacitive coupling and transformer coupling are both examples of ac coupling, which blocks the dc voltage.

Direct coupling is different. In Fig. 2 (c) there is a direct connection between the collector of the first transistor and the base of the second transistor. Because of this, both the dc and the ac voltages are coupled. Since there is no lower frequency limit, a direct-coupled amplifier is sometimes called a *dc amplifier.*

Ranges of Frequency

An **audio amplifier** refers to an amplifier that operates in the range of 20 Hz to 20 kHz. On the other hand, a **radio-frequency (RF) amplifier** is one that amplifies frequencies above 20 kHz, usually much higher.

The RF amplifiers in AM radios amplify frequencies between 535 and 1605 kHz, and the RF amplifiers in FM radios amplify frequencies between 88 and 108 MHz.

Amplifiers are also classified as **narrowband** or **wideband.** A narrowband amplifier works over a small frequency range like 450 to 460 kHz. Narrowband amplifiers are a usually tuned RF amplifier, which means that their ac load is a high-*Q* resonant tank tuned to a radio station or television channel.

A wideband amplifier operates over a large frequency range like 0 to 1 MHz. Wideband amplifiers are usually untuned; that is, their ac load is resistive.

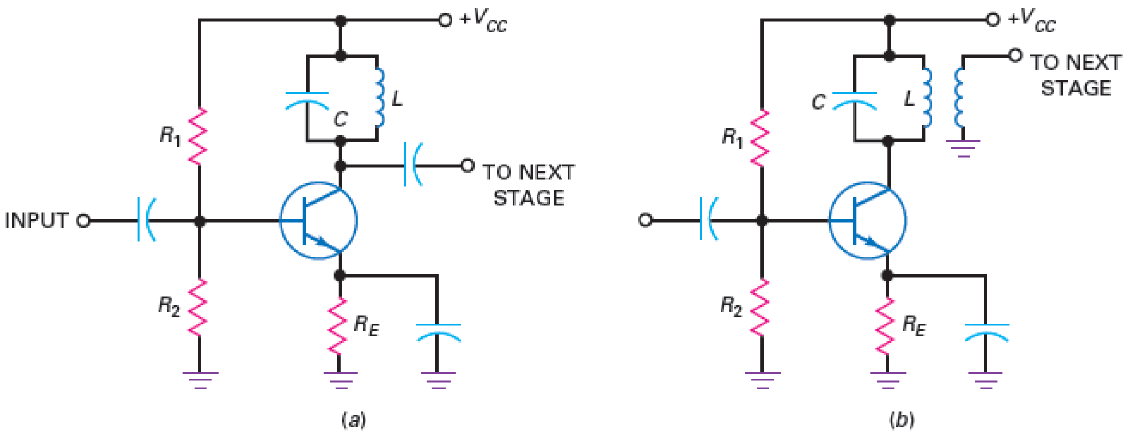


Figure 3: Tuned RF amplifiers: (*a*) capacitive coupling; (*b*) transformer coupling.

Figure 3 (a) is an example of a tuned RF amplifier. The *LC* tank is resonant at some frequency. If the tank has a high *Q*, the bandwidth is narrow. The output is capacitively coupled to the next stage.

Figure 3 (b) is another example of a tuned RF amplifier. This time, the narrowband output signal is transformer-coupled to the next stage.

Class- A Operation

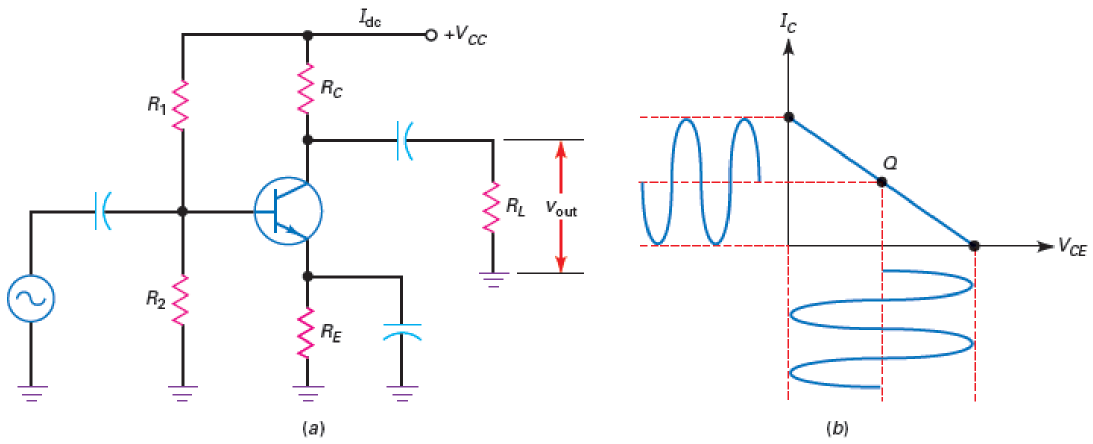


Figure 4: Class-A amplifier.

The amplifier in Fig. 4(a) is a Class-A amplifier as long as the output signal is not clipped. With this kind of amplifier, collector current flows throughout the cycle i.e. no clipping of the output signal occurs at any time during the cycle.

Power Gain

Besides voltage gain, any amplifier has a **power gain,** defined as:

$$Ap = \frac{Pout}{Pin}$$

In words, the power gain equals the ac output power divided by the ac input power. For instance, if the amplifier has an output power of 10 mW and an input power of 10 μW, it has a power gain of

$$Ap = \frac{10mW}{10\mu W} = 1000$$

Output Power

If we measure the output voltage in rms volts, the output power is given by:

$$Pout = \frac{V^2rms}{RL}$$

Usually, we measure the output voltage in peak-to-peak volts with an oscilloscope. In this case, a more convenient equation to use for output power is

$$P_{out} = \frac{Vout^2}{8RL}$$

The factor of 8 in the denominator occurs because $v_{p-p} = 2\sqrt{2}\,Vrms$

The maximum output power occurs when the amplifier is producing the maximum peak-to-peak output voltage, as shown in Fig. 4(b) In this case, v_{p-p} equals the maximum peak-to-peak output voltage and the maximum output power is

$$P_{out} = \frac{MPP^2}{8RL}$$

Transistor Power Dissipation

When no signal drives the amplifier in Fig. 4 a, the quiescent power dissipation is $P_{DQ} = V_{CEQ} I_{CQ}$

i.e. the quiescent power dissipation equals the dc voltage times the dc current. When a signal is present, the power dissipation of a transistor decreases because the transistor converts some of the quiescent power to signal power.

Efficiency

The dc power supplied to an amplifier by the dc source is

$$P_{dc} = V_{Cc} I_{dc}$$

To compare the design of power amplifiers, we can use the **efficiency,** defined by

$$\nu = \frac{P_{out}}{P_{dc}}\ x\ 100\%$$

This equation says that the efficiency equals the ac output power divided by the dc input power. The higher the efficiency, the better the amplifier is at converting dc power to ac power. The maximum efficiency of a Class-A amplifier is 25 percent.

Class-B Operation (PUSH-PULL Amplifier)

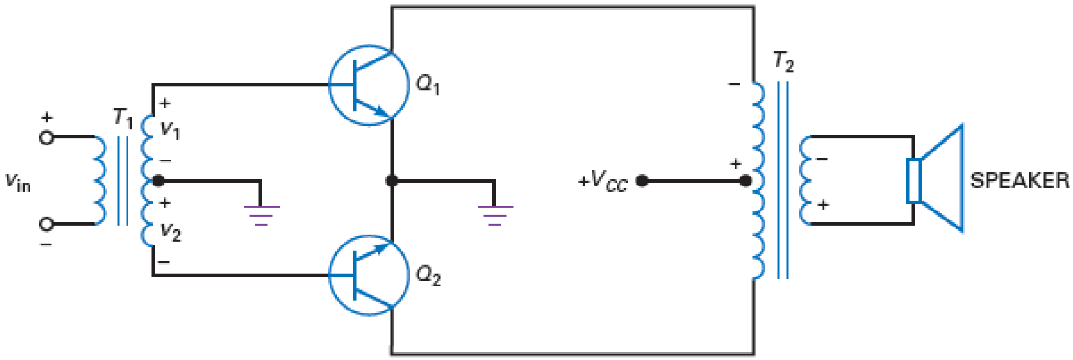


Fig. 5: Class-B push-pull amplifier.

Figure 5 shows a basic Class-B amplifier. When a transistor operates as Class-B, it clips off half a cycle. To avoid the resulting distortion, we can use two transistors in a push-pull arrangement. **Push-pull** means that one transistor conducts for half a cycle while the other is off, and vice versa.

Working:

On the positive half-cycle of input voltage, the secondary winding of *T*1 has voltage *v*1 and *v*2, as shown. Therefore, the upper transistor conducts and the lower one cuts off. The collector current through *Q*1 flows through the upper half of the output primary winding. This produces an amplified and inverted voltage, which is transformer-coupled to the loudspeaker.

On the next half-cycle of input voltage, the polarities reverse. Now, the lower transistor turns on and the upper transistor turns off. The lower transistor amplifies the signal, and the alternate half-cycle appears across the loudspeaker.

Since each transistor amplifies one-half of the input cycle, the loudspeaker receives a complete cycle of the amplified signal.

Advantages and Disadvantages

Since there is no bias in Fig.5, each transistor is at cutoff when there is no input signal, an advantage because there is no current drain when the signal is zero.

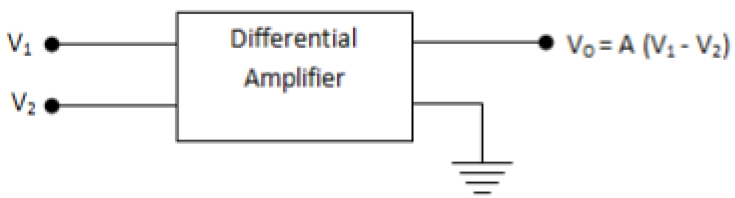
Another advantage is improved efficiency where there is an input signal. The maximum efficiency of a Class-B push-pull amplifier is 78.5 percent, so a Class-B push-pull power amplifier is more commonly used for an output stage than a Class-A power amplifier.

The main disadvantage of the amplifier shown in Fig. 5 is the use of transformers. Audio transformers are bulky and expensive. Although widely used at one time, a transformer-coupled amplifier like Fig. 5 is no longer popular. Newer designs have eliminated the need for transformers in most applications.

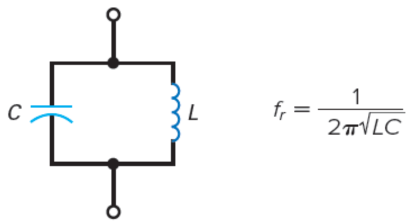
UNIVERSITY QUESTIONS

1) Enlist four classes of Amplifiers [1]
2) What is crossover distortion in Push Pull amplifiers? Draw the circuit diagram for class B push pull amplifier. How cross over distortion can be eliminated?[8]
3) Define differential amplifier.[1]

   Ans: Differential Amplifier is a device that is used to **amplify** the **difference in voltage** of the two input signals.



4) Calculate resonant frequency of a tank circuit having capcitor of 470pF and inductor of 2μH.[2]



Ans: The resonant frequency of a tank circuit $= f_r = \frac{1}{2\pi\sqrt{LC}}$

$$= \frac{1}{2x3.14\sqrt{2x10^{-6}x470x10^{-12}}}$$

$=0.192$ MHz