Distortion in Power Amplifiers

An amplifier should produce an output waveform which does not differ from the input signal waveform in any respect except amplitude, i.e., the output is an amplified signal of the input. The difference between the output waveform and the input waveform in an amplifier is called distortion.

Crossover Distortion

This is caused by non-linearity of the input characteristic of the transistors. Transistors do not turn ON at zero volt applied to the emitter junction but only when the emitter junction is forward biased by the cut-in voltage $V_\gamma = 0.3\ V$ for germanium and $0.7\ V$ for silicon. As a result, the sinusoidal base voltage excitation will not result in a sinusoidal output current. The distortion caused by non-linear transistor input characteristic is shown in Figure-1. The $i_B - v_B$ curve for each transistor is drawn and the construction used to obtain the output current is shown. In regions of small input currents (for $v_B < v_\gamma$), the output is much smaller than it would be if the response were linear. This effect is called crossover distortion.

In a Class B amplifier (Push-pull), this results in one transistor cutting off before the other begins conducting as shown in Figure 2. The distortion introduced is called so because it occurs during the time when the operation crosses over from one transistor to the other in the push-pull amplifier.

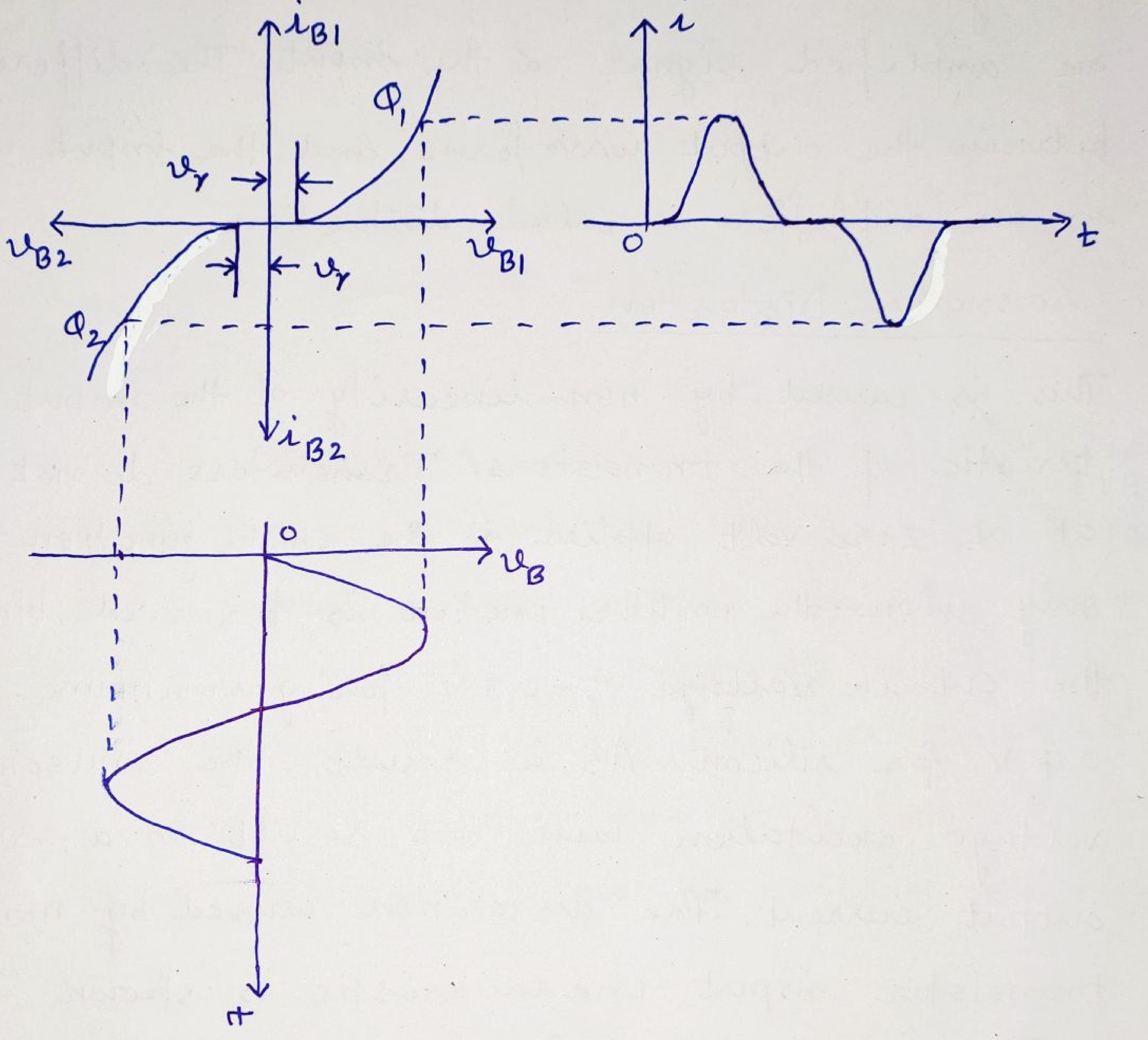

Figure 1. Cross-over distortion

To minimise crossover distortion, the transistors must operate in a Class AB mode where a small standby current flows at zero excitation. But the price that must be paid for this improvement is a loss in efficiency and waste of standby power.

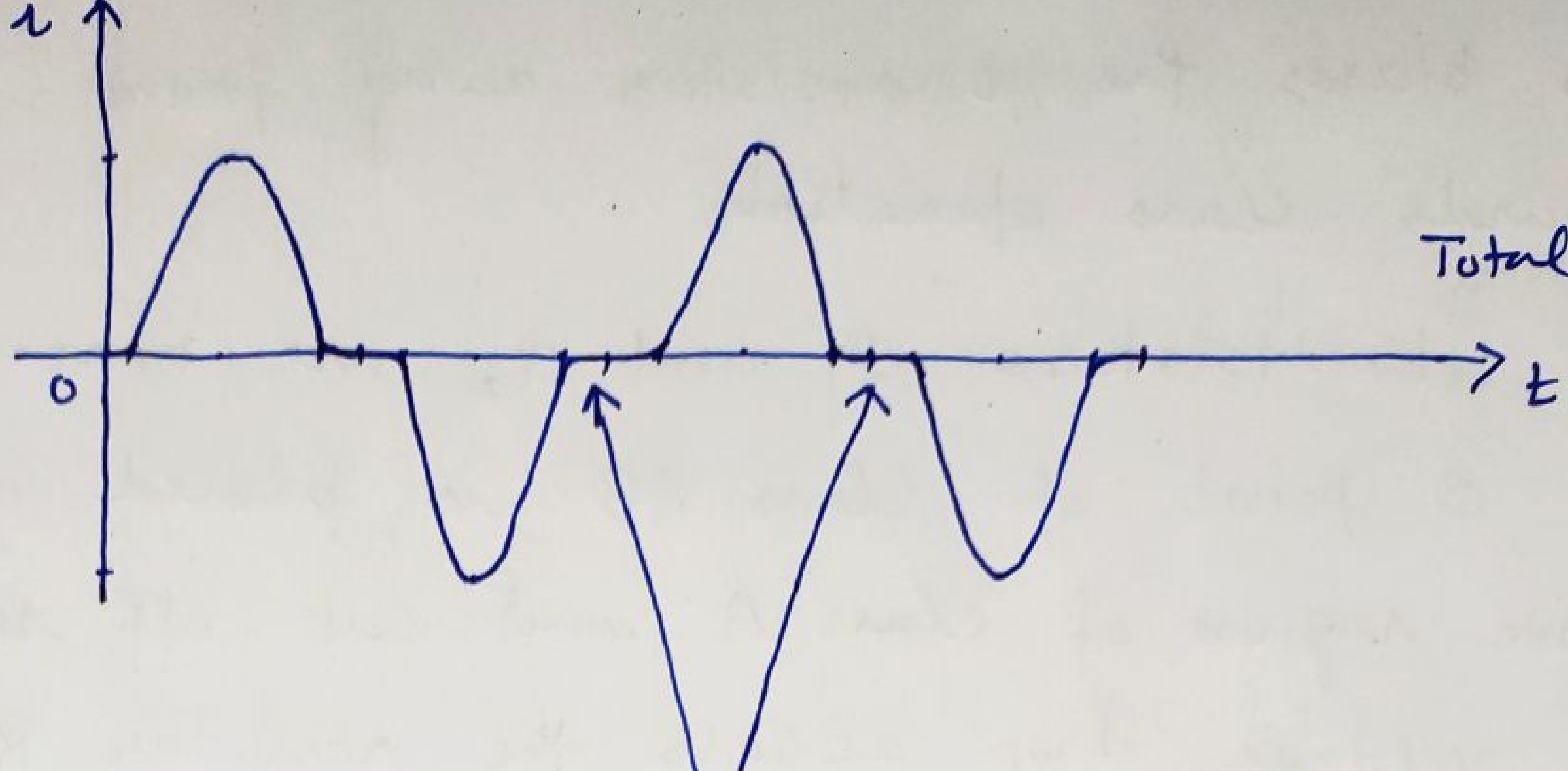

Figure 2. Crossover distortion in class B amplifier

Class AB Amplifier

A Class AB amplifier overcomes the problem of crossover distortion present in Class B amplifiers, in which a small current flows even at zero input signal level. The circuit of a Class AB amplifier is shown in Figure 3. The circuit, which is essentially the same as that of Class B amplifier, has additional R_E resistors referred to as the emitter-stabilizing resistors.

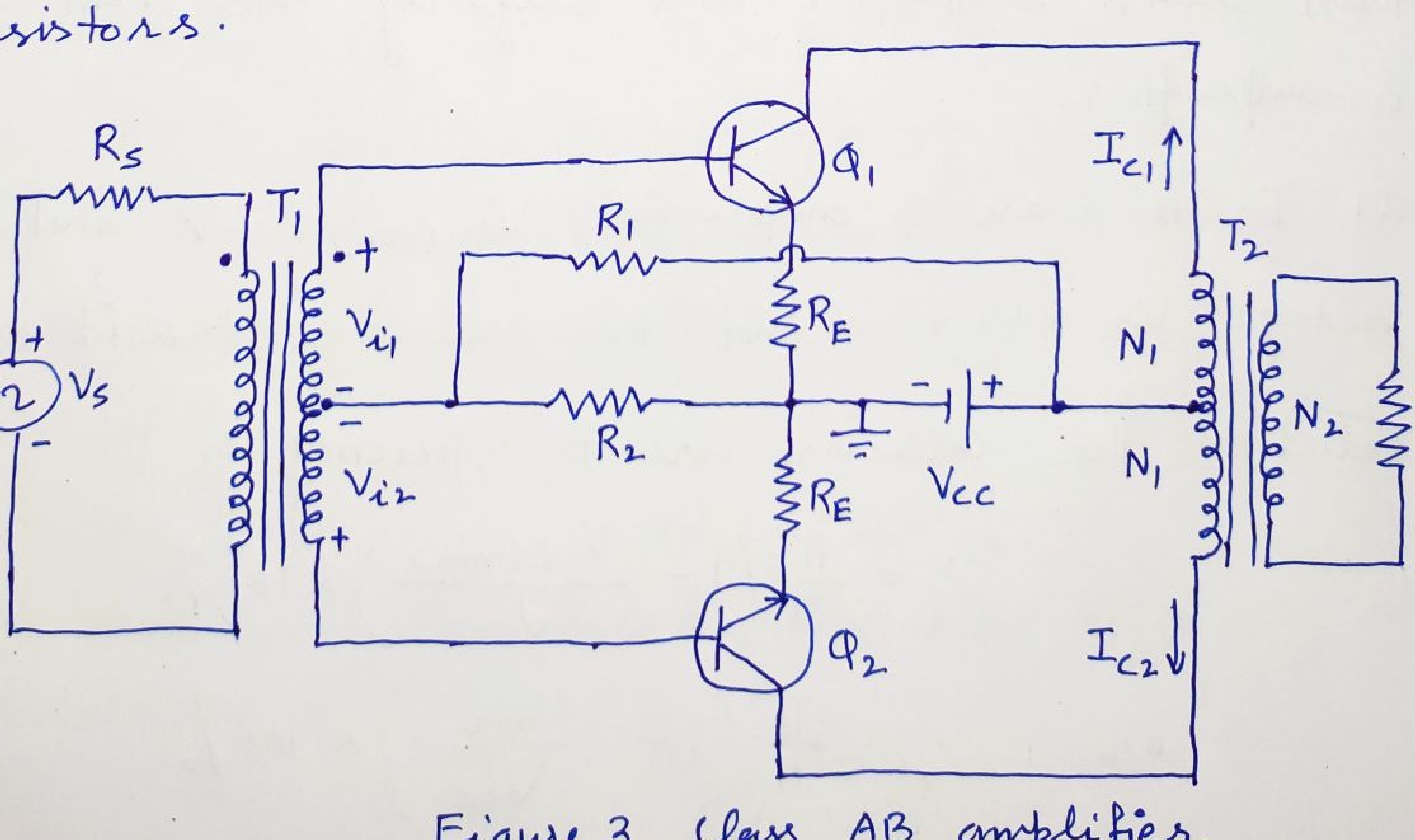

Figure 3. Class AB amplifier

This biases the transistor away from Class B slightly towards class operation.

The transistors Q_1 and Q_2 are biased such that the Q point of Class AB is placed in between the active region of class A and cut-off region of Class B. The voltage drop across the resistor R_2 is approximately equal to the cut-in voltage of the transistor. The transistors, therefore, conduct for more than 180°, so that the crossover distortion present in class B is eliminated.

When ac signal is applied to the base, the collector current starts flowing immediately. But there will be a decrease in the output power due to the negative feedback effect.

Note: The efficiency of class AB amplifier is greater than class A amplifier and slightly less than Class B amplifier.

Q1. In a Class B amplifier, $V_{CE(min)} = 2V$ and supply voltage $V_{CC} = 15\,V$. Find the collector circuit efficiency.

Solution: The collector circuit efficiency is

$$\eta = \frac{\pi}{4}\left(1 - \frac{V_{CE(min)}}{V_{CC}}\right) \times 100\%$$

or $$\eta = \frac{\pi}{4}\left(1 - \frac{V_{min}}{V_{CC}}\right) \times 100\%$$

$$\therefore \eta = \frac{\pi}{4}\left(1 - \frac{2}{15}\right) \times 100\,\%$$

$$\eta = \frac{\pi}{4}\left(\frac{13}{15}\right) \times 100\,\% = 68.06\,\%$$

MCQ

Q1. A power amplifier in which the transistor is ON for a full cycle (360°) of signal input is:

(a) Class A (b) Class B

(c) Class C (d) Class AB

Q2. The amplifier that suffers mainly from the problem of crossover distortion is:

(a) Class A (b) Class B

(c) Class AB (d) Class C

Q3. Maximum theoretical conversion efficiency of class A series fed amplifier is:

(a) 15 % (b) 25 %

(c) 50 % (d) 78.5 %

Q4. Maximum theoretical conversion efficiency of class A transformer coupled amplifier is:

(a) 15 % (b) 25 %

(c) 50 % (d) 78.5 %

Q.5. Maximum theoretical conversion efficiency of class B amplifier is:

(a) 25 % (b) 50 %

(c) 78.5 % (d) 90 %

Oscillators

Any circuit which is used to generate a periodic voltage without an ac input signal is called an oscilltor. To generate the periodic voltage, the circuit is supplied with energy from a dc source. If the output voltage is a sine wave function of time, then the oscillator is called a "sinusoidal" or "harmonic" oscillator. Positive feedback and negative resistance oscillators belong to this category.

There is another category of oscillators which generate non sinusoidal waveforms such as square, rectangular, triangular or sawtooth waves, known as "relaxation" oscillator.

Oscillators are classified in the following different ways:

1. According to the waveforms generated
   (a) Sinusoidal oscillator
   (b) Relaxation oscillator
2. According to the fundamental mechanism involved:
   (a) Negative resistance oscillators : It uses negative resistance of the amplying device to neutralize the positive resistance of the oscillator.
   (b) Feedback Oscillators : It uses positive feedback in the feedback amplifier to satisfy the Barkhausen criterion for oscillation.

3. According to the frequency generated:
   (a) Audio frequency Oscillator (AFO): up to 20 KHz
   (b) Radio frequency Oscillator (RFO): 20 KHz to 30 MHz
   (c) Very High frequency oscillator : 30 MHz to 300 MHz
   (d) Ultra High frequency oscillator : 300 MHz to 3 GHz
   (e) Microwave frequency Oscillator: above 3 GHz.
4. According to the type of circuit used, Sine-wave oscillators may be classified as,
   (a) LC tuned Oscillator
   (b) RC phase-shift oscillator
