Q1. An amplifier has voltage gain with feedback of 100. If the gain without feedback changes by 20% and the gain with feedback should not vary more than 2%, determine the values of open-loop gain 'A' and feedback ratio β. ①

Solution: Given $A_f = 100$, $\frac{dA_f}{A_f} = 2\% = 0.02$

and $\frac{dA}{A} = 20\% = 0.2$

We know that

$$\frac{dA_f}{A_f} = \frac{dA}{A} \cdot \frac{1}{(1+A\beta)}$$

$$0.02 = 0.2 \times \frac{1}{(1+A\beta)}$$

$$\therefore \quad 1+A\beta = \frac{0.2}{0.02} = 10$$

Also, we know that the gain with feedback is,

$$A_f = \frac{A}{1+A\beta}$$

$$\text{i.e} \quad 100 = \frac{A}{10}$$

$$\therefore \quad A = 1000$$

Now, $1+A\beta = 10$, i.e $A\beta = 9$

$$\therefore \quad \beta = \frac{9}{A} = \frac{9}{1000} = 0.009$$

Q.2. An amplifier has a voltage gain of 400, $f_1 = 50$ Hz, $f_2 = 200$ KHz and a distortion of 10% without feedback. Determine the amplifier voltage gain, f_{1f}, f_{2f}, and

D_f when a negative feedback is applied with feedback ratio of 0.01.

Solution: Given $A = 400$, $f_1 = 50$ Hz, $f_2 = 200$ KHz

Distortion, $D = 10\%$ and $\beta = 0.01$

We know that voltage gain with feedback

$$A_f = \frac{A}{1+A\beta} = \frac{400}{1+400\times 0.01} = 80$$

New lower 3 dB frequency,

$$f_{1f} = \frac{f_1}{1+A\beta} = \frac{50}{1+400\times 0.01} = 10 \text{ Hz}$$

New upper 3 dB frequency,

$$f_{2f} = (1+A\beta)\times f_2 = (1+400\times 0.01)\times 200\times 10^3$$

$$f_{2f} = 1 \text{ MHz}$$

Distortion with feedback,

$$D_f = \frac{D}{1+A\beta} = \frac{10}{5} = 2\%$$

Classification of Power Amplifiers

Based on the amount of transistor bias and amplitude of the input signal, amplifiers can be classified as Class A, Class B, Class AB and Class C.

Class A Amplifier

In a Class A amplifier, the transistor is biased such that the output current flows and the transistor is ON for the full cycle (360°) of the input ac signal as shown in Figure (a).

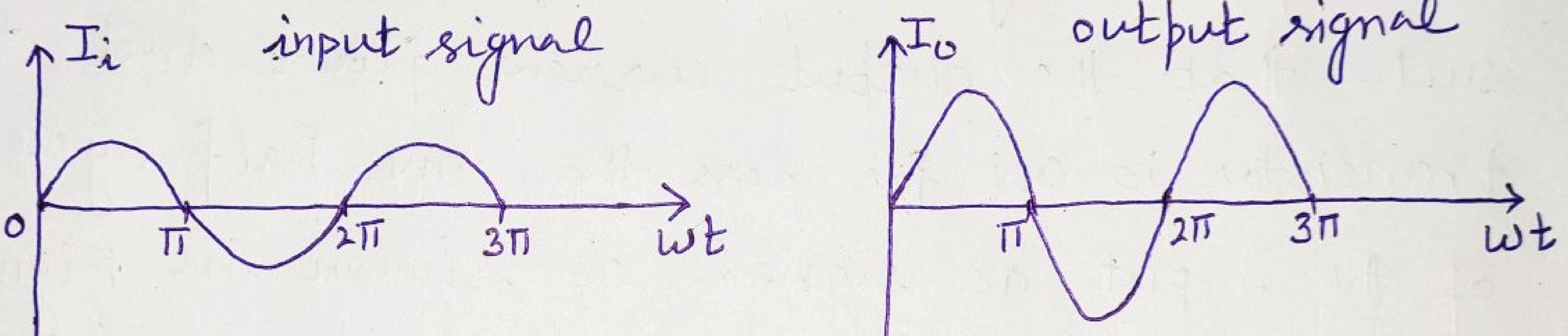

Fig. (a)

Class B Amplifier

In a Class B amplifier, the transistor bias and the amplitude of the input signal are selected such that the output current flows and the transistor is ON for only one half cycle (180°) of the input ac signal as shown in Figure (b).

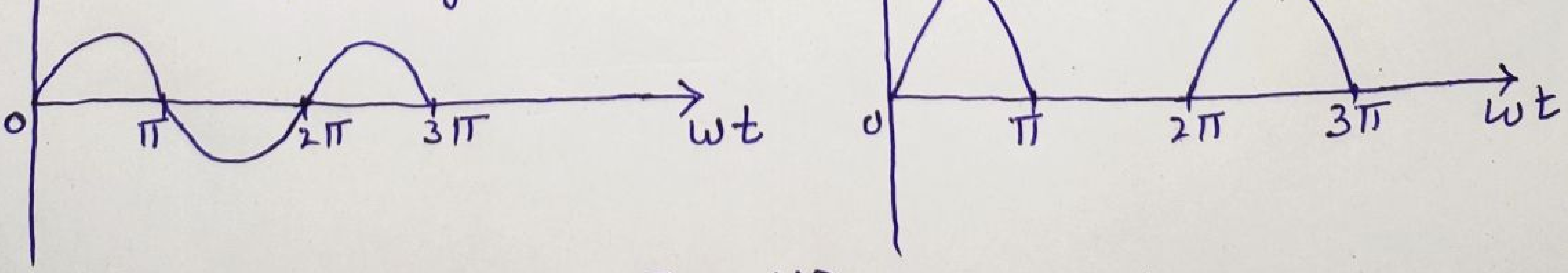

Fig (b)

Class AB Amplifier

In a Class AB amplifier, the transistor operates between the two extremes defined for Class A and Class B amplifiers. Hence, the output signal exists for more than 180° but less than 360° of the input ac signal.

Class C Amplifier

In a Class C amplifier, the transistor bias and the amplitude of the input signal are selected such that the output current flows and the transistor is ON for less than one half cycle (180°) of the input ac signal as shown in Figure (c).

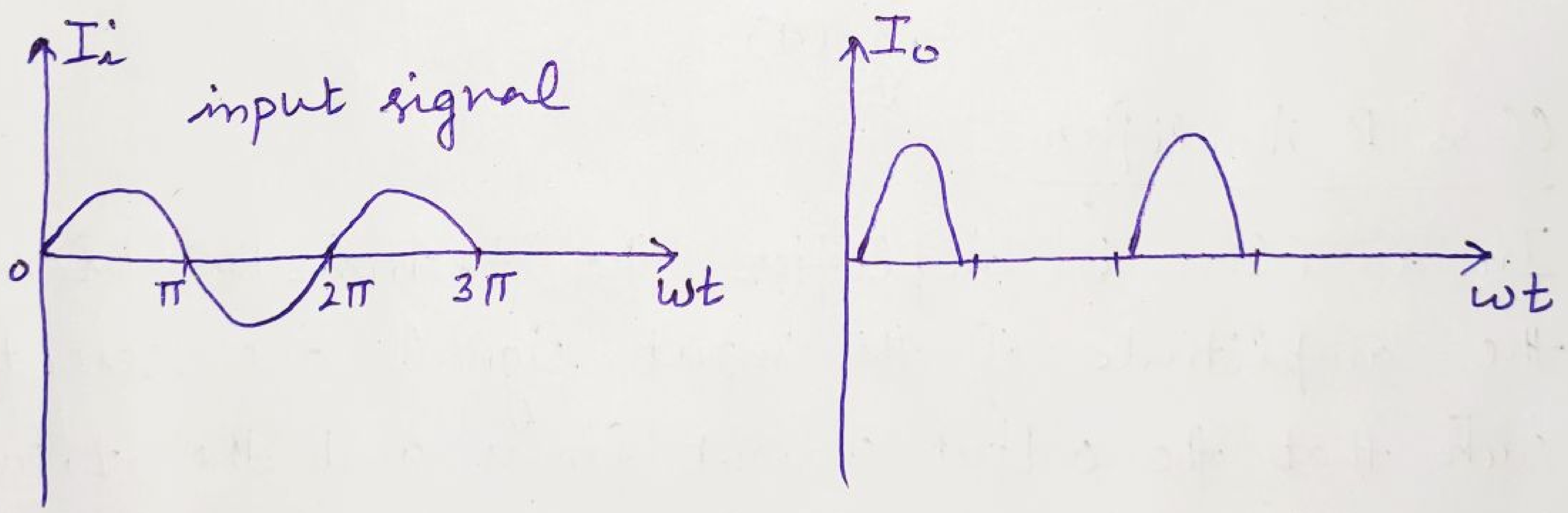

Fig. (c).

The main aim of a large-signal amplifier, otherwise called power amplifier, is to deliver a substantial amount of power to a load.

Class A Large Signal Amplifiers

A simple transistor amplifier that supplies power to a pure resistance load R_L is shown in Figure 1. Assuming that the static output characteristics are equidistant for equal increments of input base current i_B, if the input signal i_B is a sinusoidal, the output current and voltage are also sinusoidal as shown in Figure 2. i_c and v_c are instantaneous deviations from quiescent values I_c and V_c. The Power output is given by the equation $P = V_c \times I_c = I_c^2 \times R_L$, where V_c and I_c are the RMS values of the output voltage v_c and current i_c, respectively.

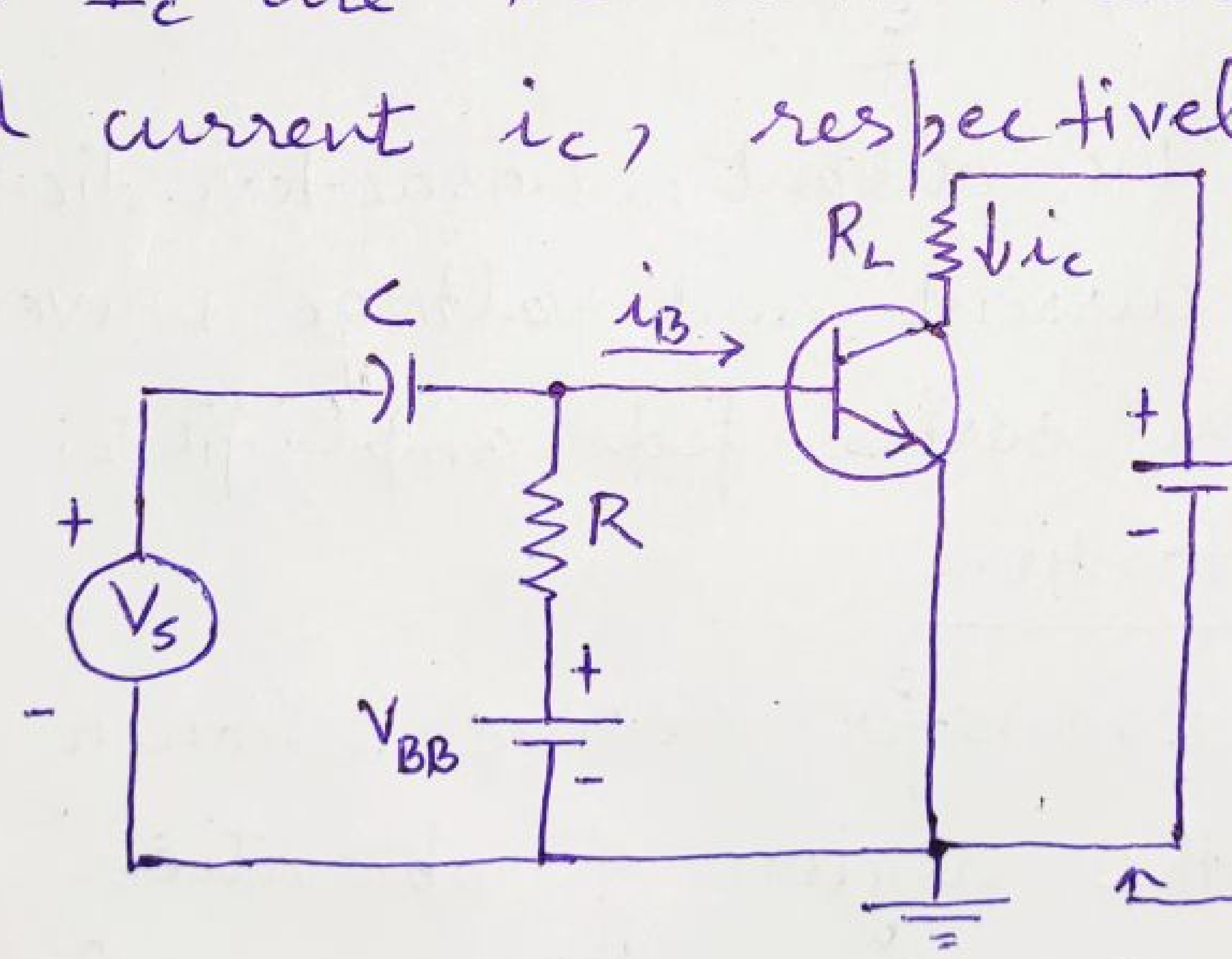

Figure 1. Simple series fed amplifier

Now,
$$I_c = \frac{I_m}{\sqrt{2}} = \frac{I_{max} - I_{min}}{2\sqrt{2}}$$

and
$$V_c = \frac{V_m}{\sqrt{2}} = \frac{V_{max} - V_{min}}{2\sqrt{2}}$$

The Power output, $P = V_c I_c = \dfrac{(V_{max} - V_{min})(I_{max} - I_{min})}{8}$

The power output can be expressed in terms of R_L as

$$P = V_c I_c = \frac{V_m I_m}{2} = \frac{I_m^2 R_L}{2} = \frac{V_m^2}{2R_L}$$

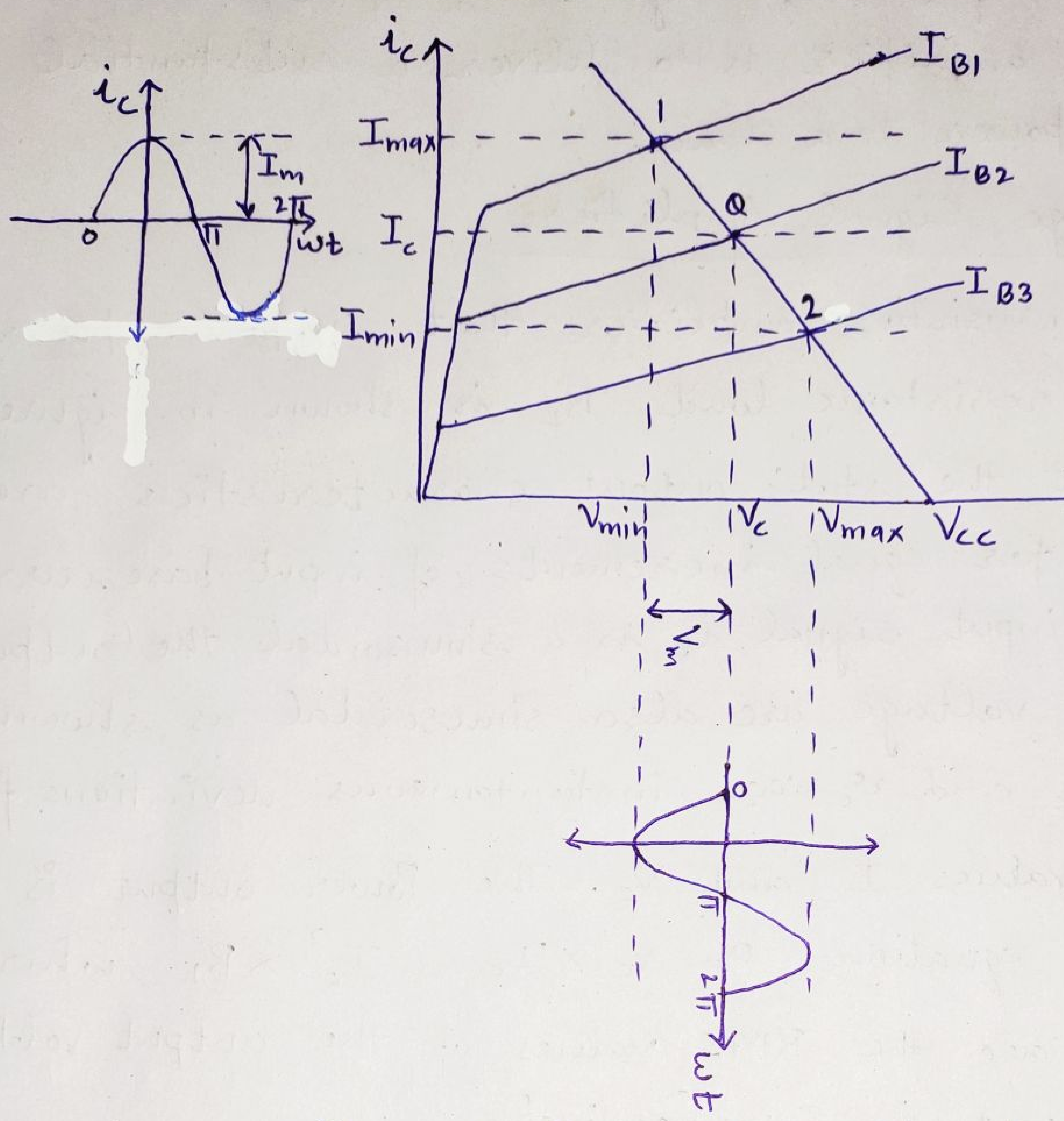

Figure 2. The output characteristics and the current and voltage waveforms for a series-fed amplifier.

Second - Harmonic Distortion

Since the dynamic transfer curve shown in Figure 3 is non-linear over the region of operation described by a parabolic equation, the output waveform differs from the input signal. Hence, this distortion is called non-linear or amplitude distortion. The output waveform now consists of fundamental and higher harmonics.

Harmonic distortion is caused by the non-linearity of the characteristic curve of an active device. The second - harmonic distortion is determined from the

dynamic transfer curve using the three-point method (3)
for small signals. The relationship between alternating current i_c and the input excitation i_b is expressed by

$$i_c = K_1 i_b + K_2 i_b^2$$

where K_1 and K_2 are constants.

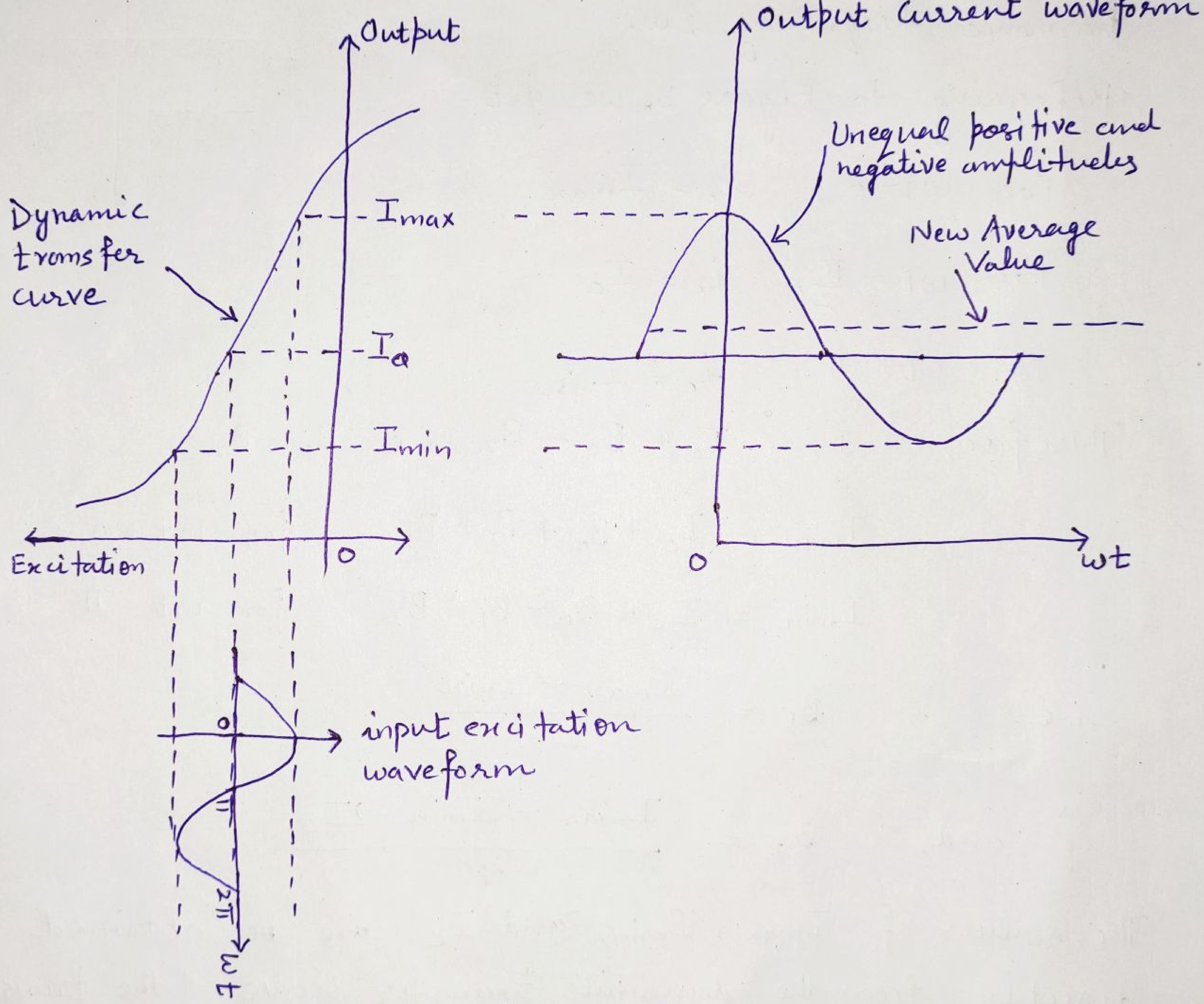

Figure 3. Dynamic transfer curve showing harmonic distortion.

Let the excitation be sinusoidal and expressed by

$$i_b = I_{bm} \cos \omega t. \text{ Therefore}$$

$$i_c = K_1 I_{bm} \cos \omega t + K_2 I_{bm}^2 \cos^2 \omega t$$

As $2\cos^2 \omega t = 1 + \cos 2\omega t$, the instantaneous total current

i_c reduces to the form

$$i_c = I_c + B_0 + B_1 \cos wt + B_2 \cos 2wt$$

where I_c is the dc component of current, B_0 is the extra dc component due to rectification of the signal, B_1 is the amplitude of the desired signal at the fundamental frequency, w, and B_2 is the amplitude of the second-harmonic frequency, 2w.

Referring to Figure 3, we get

For $wt = 0$, $i_c = I_{max}$

For $wt = \frac{\pi}{2}$, $i_c = I_c$

For $wt = \pi$, $i_c = I_{min}$

Therefore, $I_c = I_c + B_0 - B_2$, i.e $B_0 = B_2$

$$I_{max} = I_c + B_0 + B_1 + B_2 \quad \text{for } wt = 0$$

$$I_{min} = I_c + B_0 - B_1 + B_2 \quad \text{for } wt = \pi$$

i.e $$B_1 = \frac{I_{max} - I_{min}}{2}$$

and, $$B_2 = \frac{I_{max} + I_{min} - 2I_c}{4}$$

The values of I_{max}, I_{min}, and I_c can be obtained directly from the dynamic transfer curve of the transistor and from the intersection of the load line drawn on the characteristic curves.

The second-harmonic distortion D_2 in percentage is defined as

$$D_2 = \frac{|B_2|}{|B_1|} \times 100\,\%$$

If $I_c = \frac{I_{max} + I_{min}}{2}$, then B_2 and B_0 are equal to zero. Hence there is no distortion.