CLASS-B AMPLIFIER

The circuit for the class-B push pull system is the same as that for the class A system except that the devices are biased approximately at cut-off. The above circuit (class A) operates in class B if R_2 =0 because a silicon transistor is essentially at cut –off if the base is shorted to the emitter.

ADVANTAGES OF CLASS B OPERATION

(1) It is possible to obtain greater power output

(2) Efficiency is higher

(3) Negligible power loss at no signal.

DRAWBACKS OF CLASS B AMPLIFIER

(1) Harmonic distortion is higher

(2) Self bias can't be used

(3) Supply voltage must have good regulation

POWER CONSIDERATION.

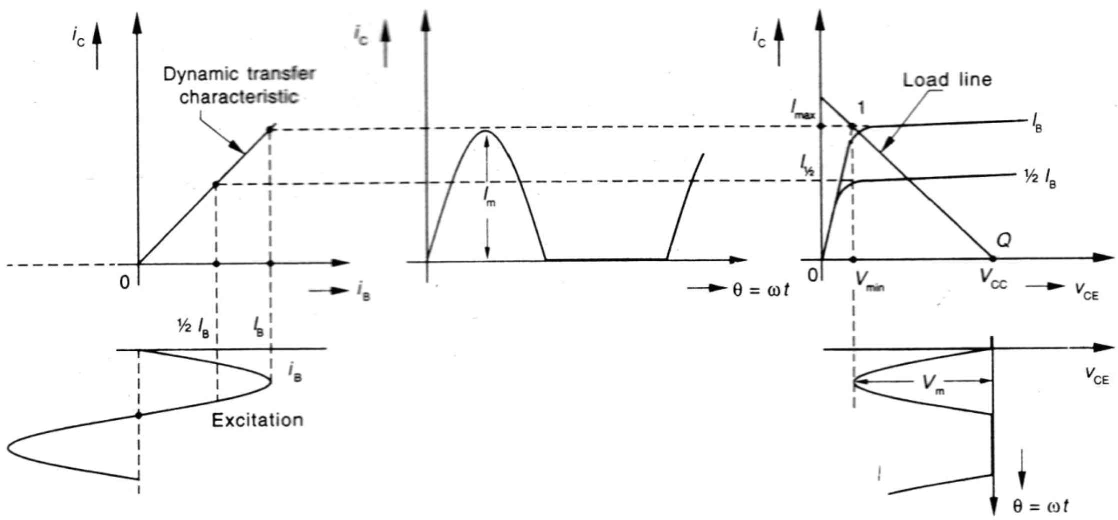

Fig. 2 Graphical construction for determining the output waveforms of a single class-B transistor stage

To investigate the power conversion efficiency of the system, it is assumed that the output characteristics are equally spaces for equal intervals of excitation, so that the dynamic transfer curve is a straight line. It also assumes that the minimum current is zero. The graphical construction from which to determine the output current & voltage wave3shapes for a single transistor operating as a class B stage is indicated in the above figure. Note that for sinusoidal excitation, the output is sinusoidal during one half of each period and is zero during the second half cycle. The effective load resistance is $R''_L = \left(\frac{N_1}{N_2}\right)^2 R_L$ where N_1 represents the number of primary turn to the center tap.

The waveform illustrated in the above figure represents one transistor Q_1 only. The output of Q_2 is, of course, a series of sine loop pulses that are 180 degrees out of phase with those of Q_1.The load current, which is proportional to the difference between the two collector currents, is therefore a perfect sine wave for the ideal conditions assumed. The power output is

$$P = \frac{I_m I_m}{2} = \frac{I_m\left(V_{CC} - V_{\min}\right)}{2} \quad \text{-------------------------- (1)}$$

The corresponding direct collector current ion each transistor under load is the average value of the half sine loop since $I_{dc} = \frac{I_m}{\pi}$ for this waveform, the dc input power from the supply is,

$$P_i = 2\frac{I_m V_{CC}}{\pi} \quad \text{----------------------- (2)}$$

The factor 2 in this expression arises because two transistors are used in the push-pull system. From equations (1) and (2) ,

$$\eta = \frac{P_0}{P_i} X100 = \frac{\pi}{4}\frac{V_m}{V_{CC}} = \frac{\pi}{4}\left(1 - \frac{V_{\min}}{V_{CC}}\right) X100\%$$

Since $V_{\min} \angle\angle V_{CC}$

$$\eta = \frac{\pi}{4} X100\% = 78.5\% \quad \text{---------------------- (3)}$$

The large value of η results from the fact that there is no current in a class B system if there is no excitation, where as there is a drain from the power supply in class A system even at zero signal.

POWER DISSIPATION

The power dissipation P_C in both transistors is the difference between the ac power output and dc power input.

$$P_C = P_{dc} - P_{ac} = P_i - P_0$$

$$= \frac{2}{\pi} V_{CC} I_m - \frac{V_m I_m}{2}$$

$$= \frac{2}{\pi} V_{CC} \frac{V_m}{R'_L} - \frac{V_m^{\ 2}}{2R_L'} \quad \text{---------------------------- (5)}$$

This equation shows that the collector dissipation is zero at no signal $\left(V_{m=} = 0\right)$,

Rises as V_m is increases and passes through a maximum at $V_m = \frac{2V_{CC}}{\pi}$.

MAXIMUM POWER DISSIPATION

The condition for maximum power dissipation can be found by differentiating eq.(5) wrt V_m and equating it to zero.

$$\frac{dP_C}{dV_m} = \frac{2}{\pi}\frac{V_{CC}}{R_L^{'}} - \frac{2V_m}{2R_L^{'}} = 0$$

$$\frac{V_m}{R_L^{'}} = \frac{2}{\pi}\frac{V_{CC}}{R_L^{'}}$$

$$\therefore V_m = \frac{2}{\pi}V_{CC} \quad \text{------------------------------------ (6)}$$

Substituting the value of V_m in eq.(5), we get

$$\text{P } P_{C,\max} = \frac{2}{\pi}\frac{V_{CC}}{R_L^{'}}\left(\frac{2}{\pi}V_{CC}\right) - \left(\frac{2}{\pi}V_{CC}\right)^2 X \frac{1}{2R_L^{'}}$$

$$= \frac{4V_{CC}^{\ 2}}{\pi^2 R_L^{'}} - \frac{2}{\pi^2}\frac{V_{CC}^{\ 2}}{R_L^{'}} = \frac{2}{\pi^2}\frac{V_{CC}^{\ 2}}{R_L^{'}} \quad \text{------------- (7)}$$

Output power, $P_0 = \frac{V_m^{\ 2}}{2R_L^{'}}$

When $V_m = V_{CC}$

$$P_{0,\max} = \frac{V_{CC}^{\ 2}}{2R_L^{'}} \quad \text{--- (8)}$$

Equation (7) can be written as

$$P_{C,\max} = \frac{4}{\pi^2}\left(\frac{V_{CC}^{\ 2}}{2R_L^{'}}\right) = \frac{4}{\pi^2}P_{0,\max}$$

$$P_{C,\max} = \frac{4}{\pi^2}P_{0,\max} = 0.4P_{0,\max} \quad \text{---------------------- (9)}$$

Equation (9) gives the maximum power dissipated by both the transistors and therefore the maximum power dissipation per transistor is, $\frac{P_{C,\max}}{2}$.

$$\therefore P_{C,\max} \text{ per transistor} = \frac{4}{\pi^2}\frac{P_{0,\max}}{2} = 0.2P_{0,\max} \quad \text{----- (10)}$$

If, for e.g. 10W maximum power is to be delivered from a class B push-pull amplifier to the load, then power dissipation ratio of each transistor should be 0.2 X 10W=2W.

HARMONIC DISTORTION

The output of a push-pull system always possesses mirror symmetry, so that $I_C = 0, I_{max} = -I_{min}$ & $I_{\frac{1}{2}} = -I_{-\frac{1}{2}}$

We know that $$B_0 = \frac{1}{6}\left[I_{max} + 2I_{\frac{1}{2}} + 2I_{-\frac{1}{2}} + I_{min}\right] - I_C$$

$$B_1 = \frac{1}{3}\left[I_{max} + I_{\frac{1}{2}} - I_{-\frac{1}{2}} - I_{min}\right]$$

$$B_2 = \frac{1}{4}\left[I_{max} - 2I_C + I_{min}\right]$$

$$B_3 = \frac{1}{6}\left[I_{max} - 2I_{\frac{1}{2}} + 2I_{-\frac{1}{2}} - I_{min}\right]$$

$$B_4 = \frac{1}{12}\left[I_{max} - 4I_{\frac{1}{2}} + 6I_C - 4I_{-\frac{1}{2}} + I_{min}\right]$$

When $I_C = 0, I_{max} = -I_{min}$ & $I_{\frac{1}{2}} = -I_{-\frac{1}{2}}$, the above equations reduce to

$$B_0 = B_2 = B_4 = 0 \quad \text{------------------------ (11)}$$

$$B_1 = \frac{2}{3}\left(I_{max} + I_{\frac{1}{2}}\right) \quad \text{------------------------ (12)}$$

$$B_3 = \frac{1}{3}\left(I_{max} - 2I_{\frac{1}{2}}\right) \text{------------------------ (13)}$$

Note that there is no even harmonic distortion. The major contribution to distortion is the third harmonic and is given by ,

$$D_3 = \frac{|B_3|}{|B_1|} \times 100\% \quad \text{------------------------- (14)}$$

The output power taking distortion into account is given by

$$P_0 = (1 + D_3)^2 \frac{B_1{}^2 R_L{}'}{2} \quad \text{---------------------} \ (15)$$

SPECIAL CIRCUITS

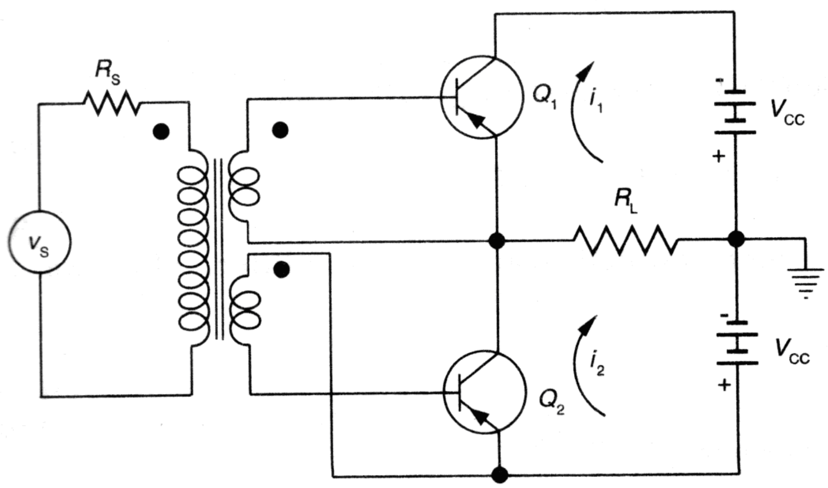

Fig 3

A circuit that avoids using the output transformer is shown above. This configuration requires a power supply whose centre tap is grounded. Here, high powered transistors are used. They have a collector to emitter output impedance in the order of 4Ω to 8Ω.This allows single ended push-pull operation. The voltage developed across the load is again due to the difference in collector currents $i_1 - i_2$, so this is a true push-pull application.