Class A power Amplifier

- A Class A power amplifier is one in which the output current flows for the entire cycle of the AC input supply. Hence the complete signal present at the input is amplified at the output. shows the circuit diagram

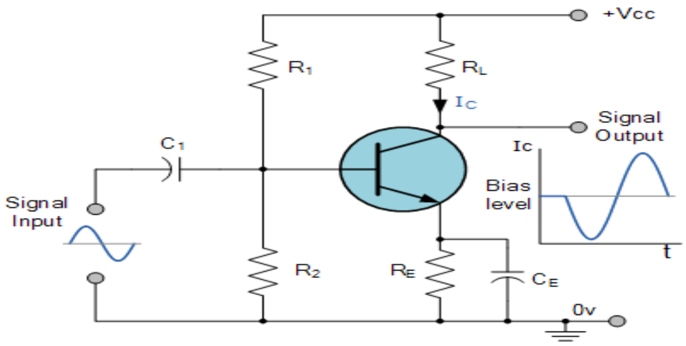


Fig.1 Class A Power amplifier.

(Source: Microelectronics byJ. Millman and A. Grabel,)

- From the above figure, it can be observed that the transformer is present at the collector as a load. The use of transformer permits the impedance matching, resulting in the transference of maximum power to the load e.g. loud speaker.

- The operating point of this amplifier is present in the linear region. It is so selected that the current flows for the entire ac input cycle. The below figure explains the selection of operating point.

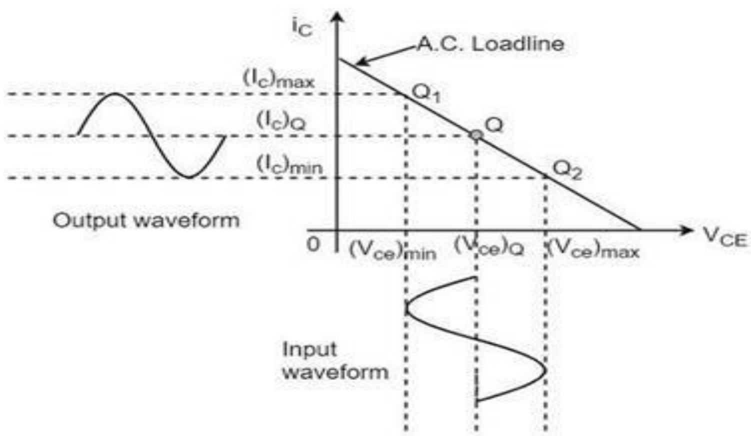


Fig.2 AC load line

(Source: Microelectronics byJ. Millman and A. Grabel,)

- The output characteristics with operating point Q is shown in the figure above. Here $(I_c)_Q$ and $(V_{ce})_Q$ represent no signal collector current and voltage between collector and emitter respectively. When signal is applied, the Q-point shifts to Q_1 and Q_2. The output current increases to $(I_c)_{max}$ and decreases to $(I_c)_{min}$. Similarly, the collector-emitter voltage increases to $(V_{ce})_{max}$ and decreases to $(V_{ce})_{min}$.

D.C. Power drawn from collector battery V_{cc} is given by

$$P_{in} = \text{voltage} \times \text{current} = V_{CC}(I_C)_Q$$

This power is used in the following two parts

- Power dissipated in the collector load as heat is given by

$$P_{RC} = (\text{current})^2 \times \text{resistance} = (I_C)^2_Q R_C$$

- Power given to transistor is given by

$$P_{tr} = P_{in} - P_{RC} = V_{CC} - (I_C)^2_Q R_C$$

When signal is applied, the power given to transistor is used in the following two parts −

- A.C. Power developed across load resistors RC which constitutes the a.c. poweroutput.

$$(P_O)_{ac} = I^2 R_C = V^2 / R_C = (V_m/\sqrt{2})^2 / R_C = V_m^2 / 2R_C$$

- Where **I** is the R.M.S. value of a.c. output current through load, **V** is the R.M.S. valueof a.c. voltage, and $\mathbf{V_m}$ is the maximum value of V.
- The D.C. power dissipated by the transistor (collector region) in the form of heat, i.e., $(P_C)_{dc}$

- This class A power amplifier can amplify small signals with least distortion and the output will be an exact replica of the input with increased strength.
- Let us now try to draw some expressions to represent efficiencies.

Overall Efficiency

The overall efficiency of the amplifier circuit is given by

$$(\eta)_{overall} = \frac{a.c\,power\ delivered\ to\ the\ load}{total\ power\ delivered\ by\ d.c\ supply}$$

$$= \frac{(P_O)_{ac}}{(P_{in})_{dc}}$$

Collector Efficiency

The collector efficiency of the transistor is defined as

$$(\eta)_{collector} = \frac{average\ a.c\,power\ output}{average\ d.c\,power\ input\ to\ transistor}$$

Expression for overall efficiency

$$(P_O)_{ac} = V_{rms} \times I_{rms}$$

$$= \frac{1}{\sqrt{2}}\left[\frac{(V_{ce})_{max} - (V_{ce})_{min}}{2}\right] \times \frac{1}{\sqrt{2}}\left[\frac{(I_C)_{max} - (I_C)_{min}}{2}\right]$$

$$= \frac{[(V_{ce})_{max} - (V_{ce})_{min}] \times [(I_C)_{max} - (I_C)_{min}]}{8}$$

Expressions:

$I_{BQ} = (V_{CC} - 0.7)/R_B$

$I_{CQ} = \beta I_{BQ}$

$V_{EQ} = V_{CC} - I_{CQ} R_L$

Q point at (V_{CEQ}, I_{CQ}) $P_{dc} = V_{CC} I_{CQ}$

$P_{ac} = ((V_{max} - V_{min})(I_{max} - I_{min}))/8$

Efficiency $\%\eta = (P_{ac}/P_{dc})*100$ **Power dissipation** $P_d = P_{dc} - P_{ac}$

Advantages of Class A Amplifiers

- The current flows for complete input cycle
- It can amplify small signals
- The output is same as input
- No distortion is present

Disadvantages of Class A Amplifiers

The disadvantages of Class A power amplifier are as follows

- Low power output
- Low collector efficiency

TRANSFORMER COUPLED CLASS A POWER AMPLIFIER:

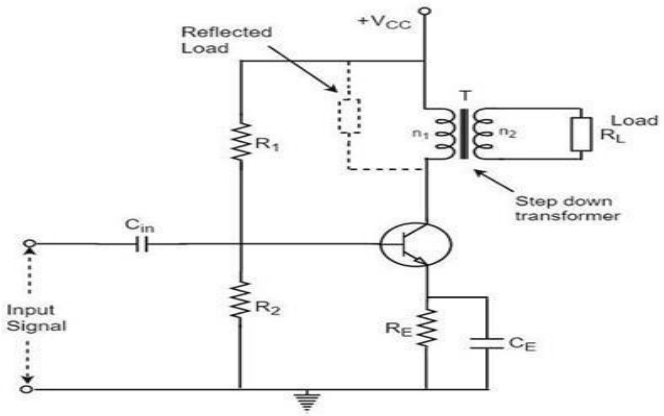


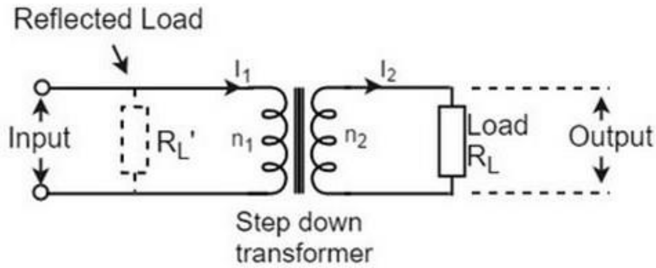
Fig.3 Transformer coupled class A amplifier
(Source: Microelectronics byJ. Millman and A. Grabel,)

- The **construction of class A power amplifier** can be understood with the help of above figure. This is similar to the normal amplifier circuit but connected with a transformer in the collector load.

- Here R1 and R2 provide potential divider arrangement. The resistor Re provides stabilization, Ce is the bypass capacitor and Re to prevent a.c. voltage. The transformer used here is a step-down transformer. The high impedance primary of the transformer is connected to the high impedance collector circuit. The low impedance secondary is connected to the load (generally loud speaker).

Transformer Action:

- The transformer used in the collector circuit is for impedance matching. R_L is the load connected in the secondary of a transformer. R_L' is the reflected load in the primary of the transformer.
- The numbers of turns in the primary are n_1 and the secondary are n_2. Let V_1 and V_2 be the primary and secondary voltages and I_1 and I_2 be the primary and secondary currents respectively. The below figure shows the transformer clearly.



We know that

$$\frac{V_1}{V_2} = \frac{n_1}{n_2} \; and \; \frac{I_1}{I_2} = \frac{n_1}{n_2}$$

Or

$$V_1 = \frac{n_1}{n_2} V_2 \; and \, I_1 = \frac{n_1}{n_2} I_2$$

Hence

$$\frac{V_1}{I_1} = \left(\frac{n_1}{n_2}\right)^2 \frac{V_2}{I_2}$$

But $V_1/I_1 = R_L'$ = effective input resistance

And $V_2/I_2 = R_L$ = effective output resistance

Therefore,

$$R'_L = \left(\frac{n_1}{n_2}\right)^2 R_L = n^2 R_L$$

Where

$$n = \frac{number\, of\, turns\, in\, primary}{number\, of\, turns\, in\, secondary} = \frac{n_1}{n_2}$$

- A power amplifier may be matched by taking proper turn ratio in step down transformer.

Circuit Operation

- If the peak value of the collector current due to signal is equal to zero signal collector current, then the maximum a.c. power output is obtained. So, in order to achieve complete amplification, the operating point should lie at the center of the load line.
- The operating point obviously varies when the signal is applied. The collector voltage varies in opposite phase to the collector current. The variation of collector voltage appears across the primary of the transformer.

Circuit Analysis:

- The power loss in the primary is assumed to be negligible, as its resistance is very small.
- The input power under dc condition will be

$$(P_{in})_{dc} = (P_{tr})_{dc} = V_{CC} \times (I_C)_Q$$

Under maximum capacity of class A amplifier, voltage swings from $(V_{ce})_{max}$ to zero and current from $(I_c)_{max}$ to zero.

Hence

$$V_{rms} = \frac{1}{\sqrt{2}}\left[\frac{(V_{ce})_{max} - (V_{ce})_{min}}{2}\right] = \frac{1}{\sqrt{2}}\left[\frac{(V_{ce})_{max}}{2}\right] = \frac{2V_{CC}}{2\sqrt{2}}$$

$$= \frac{V_{CC}}{\sqrt{2}}$$

$$I_{rms} = \frac{1}{\sqrt{2}}\left[\frac{(I_C)_{max} - (I_C)_{min}}{2}\right] = \frac{1}{\sqrt{2}}\left[\frac{(I_C)_{max}}{2}\right] = \frac{2(I_C)_Q}{2\sqrt{2}}$$

$$= \frac{(I_C)_Q}{\sqrt{2}}$$

Therefore,

$$(P_O)_{ac} = V_{rms} \times I_{rms} = \frac{V_{CC}}{\sqrt{2}} \times \frac{(I_C)_Q}{\sqrt{2}} = \frac{V_{CC} \times (I_C)_Q}{2}$$

Therefore,

$$\text{Collector Efficiency} = \frac{(P_O)_{ac}}{(P_{tr})_{dc}}$$

Or,

$$(\eta)_{collector} = \frac{V_{CC} \times (I_C)_Q}{2 \times V_{CC} \times (I_C)_Q} = \frac{1}{2}$$

$$= \frac{1}{2} \times 100 = 50\%$$

The efficiency of a class A power amplifier is nearly than 30% whereas it has got improved to 50% by using the transformer coupled class A power amplifier.

- **Expressions:**

$R_L' = [N_1/N_2]^2 R_L$

Q point (V_{CC}, I_{CQ}), $I_{CQ} = \beta I_{BQ}$

$P_{dc} = V_{CC} I_{CQ}$

$P_{ac} = ((V_{max} - V_{min})(I_{max} - I_{min}))/8$

Efficiency $\%\eta = (P_{ac}/P_{dc})*100$.

$\%\eta$ max= 50%

Power dissipation $P_d = P_{dc} = V_{CC} I_{CQ}$

Impedance matching is possible

Slope of dc load line ideally ∞

Advantages

The advantages of transformer coupled class A power amplifier are as follows.

- No loss of signal power in the base or collector resistors.
- Excellent impedance matching is achieved.
- Gain is high.
- DC isolation is provided.

Disadvantages

The disadvantages of transformer coupled class A power amplifier are as follows.

- Low frequency signals are less amplified comparatively.
- Hum noise is introduced by transformers.
- Transformers are bulky and costly.
- Poor frequency response.

Applications

The applications of transformer coupled class A power amplifier are as follows.

- This circuit is where impedance matching is the main criterion.
- These are used as driver amplifiers and sometimes as output amplifiers.
- When the collector current flows only during the positive half cycle of the input signal, the power amplifier is known as **class B power amplifier**.