Power amplifiers
Input signal → Power Amplifier → Output signal
A stereo automotive audio amplifier is rated at 150W of output at an efficiency of 60 %. How much current will this amplifier require when it is delivering rated output? Automotive electrical systems operate on 12V.

\[ P_{\text{in}} = 250 \text{ W} \]
\[ I = 20.8 \text{ A} \]
A100W of audio power is required in a music amplifier. Assume the power amplifier is 10% efficient. What kind of power supply is required.

\[ P_{in} = 1000 \text{ W} \]
Amplifier Gain of the Input Signal

Voltage Amplifier Gain

\[
Voltage Gain \left( A_v \right) = \frac{Output Voltage}{Input Voltage} = \frac{V_{out}}{V_{in}}
\]

Current Amplifier Gain

\[
Current Gain \left( A_i \right) = \frac{Output Current}{Input Current} = \frac{I_{out}}{I_{in}}
\]

Power Amplifier Gain

\[
Power Gain \left( A_p \right) = A_v \times A_i
\]
Amplifier Efficiency

\[
\text{Efficiency } (\eta) = \frac{\text{power delivered to the load}}{\text{d.c. power taken from the supply}} = \frac{P_{\text{out}}}{P_{\text{in}}}
\]
Power amplifiers

- Amplifiers that produce voltage amplification or current amplification also produce power amplification.
- However, the term **power amplifier** is normally reserved for circuits whose main function is to deliver large amounts of power.
- These can be designed using MOSFETs or bipolar transistors.
- When designing a power amplifier a low output resistance is required so that the circuit can deliver a high output current.
Classes of power amplifiers

• Class A Amplifier
  – has low efficiency of less than 40% but good signal reproduction and linearity

• Class B Amplifier
  – is twice as efficient as class A amplifiers with a maximum theoretical efficiency of about 70% because the amplifying device only conducts (and uses power) for half of the input signal

• Class AB Amplifier
  – has an efficiency rating between that of Class A and Class B but poorer signal reproduction

• Class C Amplifier
  – most efficient amplifier class but distortion is very high as only a small portion of the input signal is amplified
Classes of power amplifiers

Class A Amplifier
- Operating Curve
- Operating Point Q
- Input Signal
- Output Signal

Class B Amplifier
- Operating Curve
- Unused Area
- Output Signal
- Q

Class AB Amplifier
- Operating Curve
- Unused Area
- Output Signal
- Bias
- Q

Class C Amplifier
- Operating Curve
- Unused Area
- Output Signal less than 180°
- Q
- Input Signal
Classes of power amplifiers

- **Class A Amplifier**
  - Operates at centre of load line
  - Conduction angle $360^0$

- **Class B Amplifier**
  - Operates at cut off
  - Conduction angle $180^0$

- **Class AB Amplifier**
  - Operates between A and B

- **Class C Amplifier**
  - Conduction angle is small approx. $90^0$
Class A Output Stage

output voltage:
\[ v_O = v_I - v_{BE1} \]

maximum output voltage:
\[ \max(v_O) = V_{CC} - V_{CE1sat} \]

minimum output voltage:
\[ \min(v_O) = -V_{CC} + V_{CE2sat} = -IR_L \]

bias current:
\[ I \geq \frac{|-V_{CC} + V_{CE2sat}|}{R_L} \]
Class A Output Stage
Power Conversion Efficiency

Power conversion efficiency: 
\[ \eta = \frac{\text{load power} \ (P_L)}{\text{supply power} \ (P_s)} \]

Load power:
\[ P_L = \frac{\left(\frac{\hat{V}_o}{\sqrt{2}}\right)^2}{R_L} = \frac{1}{2} \frac{\hat{V}_o^2}{R_L} \]

Supply power:
\[ P_s = 2V_{cc} \ i \]

Supply power:
\[ \eta = \frac{1}{4} \left( \frac{\hat{V}_o}{IR_L} \right) \left( \frac{\hat{V}_o}{V_{cc}} \right) \]

Peak output voltage:
\[ \hat{V}_o = V_{cc} = IR_L \]

\[ \eta = \frac{1}{4} = 25\% \]
Problem #1

For the Class A output stage power amplifier $V_{cc} = 10 \, \text{V}$, $I = 100 \, \text{mA}$ and $R_L = 100\, \Omega$. If the output voltage is an 8-V peak sinusoid, find

a) The power delivered to the load
b) The average power drawn from the supplies
c) The power conversion efficiency

a) $0.32 \, \text{W}$
b) $2 \, \text{W}$
c) $16\%$