Amplifier Efficiency and Impedances
Efficiency

- Efficiency $\eta$ (eta) of a power amplifier is defined by:

$$\eta = \frac{\text{a.c. power output to load}}{\text{d.c power taken from supply}} \times 100\%$$

- Class A cannot exceed 50%
- Class B theoretically up to 100%
- Class AB – better than Class A but less than Class B
Input and Output Impedances

- **Input impedance** \( Z_{\text{in}} \) equals \( \frac{V_{\text{in}}}{I_{\text{in}}} \), where \( I_{\text{in}} \) is the a.c. input current and \( V_{\text{in}} \) is the a.c. input voltage.
  - It depends not only on transistor input resistance \( r_i \) but also any capacitors, resistors, etc. in the circuit.

- **Output impedance** \( Z_{\text{out}} \) is the a.c. equivalent of the internal or source resistance of a battery.
  - It causes a ‘loss’ of voltage at the output terminals when another circuit is connected.
Both $Z_{in}$ and $Z_{out}$ can be measured experimentally.

For maximum voltage transfer $Z_{in}$ should be at least 10 times greater than $Z_{out}$. 

\[ V_{in} = \frac{Z_{in}}{Z_{in} + Z_{out}} \times V \]
Measuring Input Impedance

A known resistor $R$ is connected in series with the signal generator supplying an a.c input signal to the device where $Z_{in}$ is required.

Voltages $V_1$ and $V_2$ are measured by a CRO. Then if $I_{in}$ is the input current, the voltage across $R$ is given by:

$$V_1 - V_2 = I_{in} \times R$$
Measuring Input Impedance

\[ V_1 - V_2 = I_{in} \times R \]

\[ I_{in} = \frac{V_1 - V_2}{R} \quad \text{but} \quad Z_{in} = \frac{V_2}{I_{in}} = \frac{V_2}{\frac{V_1 - V_2}{R}} \]

\[ Z_{in} = \frac{V_2 \times R}{V_1 - V_2} \]
Measuring Output Impedance

- To find the output impedance of an a.c. voltage source.
- Measure the open circuit voltage $V_1$.
- Then measure the output voltage $V_2$ across a known resistor $R$.
- The voltage drop across the output impedance $Z_{\text{out}}$ with $R$ connected is:
  
  $$V_1 - V_2 = I_{\text{out}} \times Z_{\text{out}}$$

  where $I_{\text{out}}$ is the output current.
Measuring Output Impedance

\[ V_1 - V_2 = I_{out} \times Z_{out} \]

\[ I_{out} = \frac{V_2}{R} \quad \text{and} \quad Z_{out} = \frac{V_1 - V_2}{I_{out}} = \frac{V_1 - V_2}{V_2/R} \]

\[ Z_{out} = \frac{(V_1 - V_2)R}{V_2} \]
Practical

- Determine the input and output impedances for the circuit given.