NETWORK ANALYSIS AND SYNTHESIS

- Substituting $\omega = 2\pi f$ and $CR = 1/\,2\pi f_C$ in the earlier equation gives

$$\frac{v_o}{v_i} = \frac{1}{1 - j\dfrac{1}{\omega CR}} = \frac{1}{1 - j\dfrac{1}{(2\pi f)\left(\dfrac{1}{2\pi f_c}\right)}} = \frac{1}{1 - j\dfrac{f_c}{f}}$$

- This is the general form of the gain of the circuit
- It is clear that both the *magnitude* of the gain and the *phase angle* vary with frequency

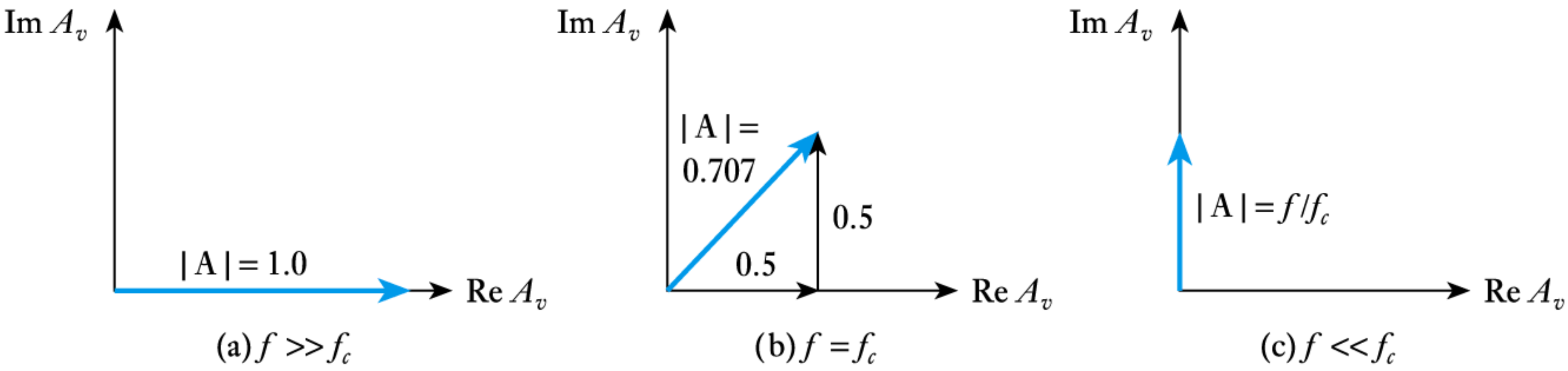
- Consider the behaviour of the circuit at different frequencies:
- **When $f >> f_c$**
  - f_c/f << 1, the voltage gain ≈ 1
- **When $f = f_c$**

$$\frac{v_o}{v_i} = \frac{1}{1 - \mathrm{j}\frac{f_c}{f}} = \frac{1}{1-\mathrm{j}} = \frac{1 \times (1+\mathrm{j})}{(1-\mathrm{j}) \times (1+\mathrm{j})} = \frac{(1+\mathrm{j})}{2} = 0.5 + 0.5\mathrm{j}$$

- **When $f << f_c$**

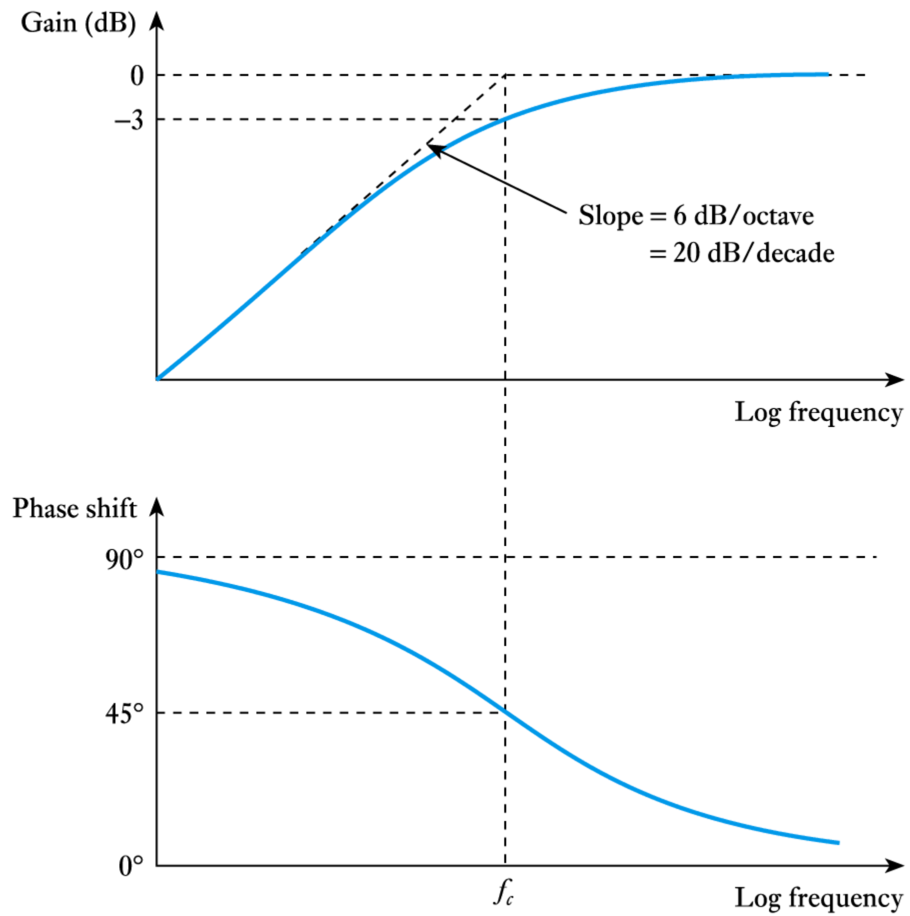
$$\frac{v_o}{v_i} = \frac{1}{1 - \mathrm{j}\frac{f_c}{f}} \approx \frac{1}{-\mathrm{j}\frac{f_c}{f}} = \mathrm{j}\frac{f}{f_c}$$

- The behaviour in these three regions can be illustrated using phasor diagrams



- At *low* frequencies the gain is linearly related to frequency. It falls at -6dB/octave (-20dB/decade)

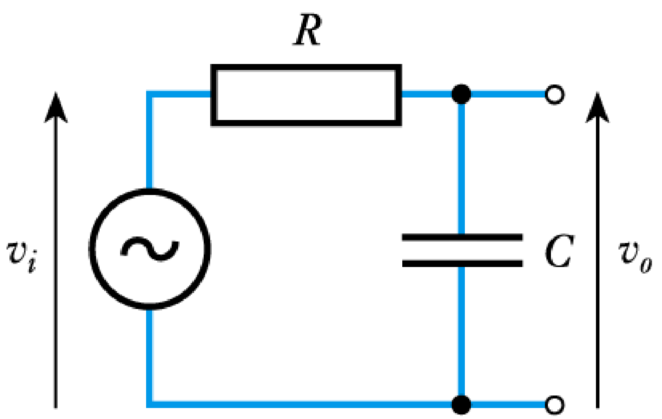
- Frequency response the high-pass netwo
  - the gain response ha two *asymptotes* that meet at the cut-off frequency
  - figures of this form a called **Bode diagram**



A Low-Pass *RC* Network

- Transposing the *C* and *R* giv

$$\frac{v_o}{v_i} = \frac{\mathbf{Z_C}}{\mathbf{Z_R} + \mathbf{Z_C}} = \frac{-\mathrm{j}\frac{1}{\omega C}}{R - \mathrm{j}\frac{1}{\omega C}} = \frac{1}{1 + \mathrm{j}\omega CR}$$

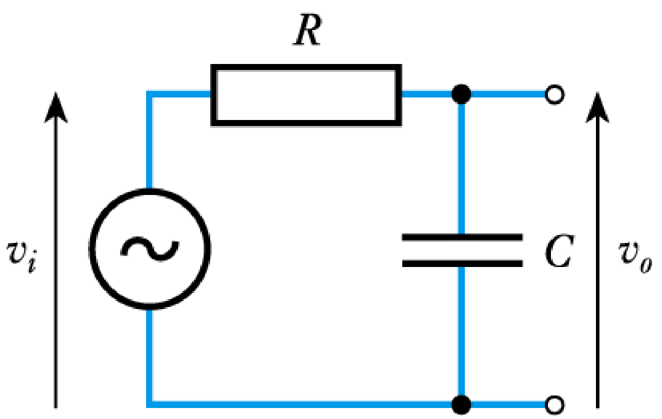


- At high frequencies
  - ω is large, voltage gain $\rightarrow 0$
- At low frequencies
  - ω is small, voltage gain ≈ 1

A Low-Pass *RC* Network

- A similar analysis to before gives

$$|\text{Voltage gain}| = \frac{1}{\sqrt{1+(\omega CR)^2}}$$



- Therefore when, when $\omega CR = 1$

$$|\text{Voltage gain}| = \frac{1}{\sqrt{1+1}} = \frac{1}{\sqrt{2}} = 0.707$$

- Which is the cut-off frequency

THANKS….

Queries Please…