Operational Amplifiers

Basics of Op Amps
Advantages of Op Amps

Compared with circuits built from separate components ICs are:

- Very much smaller – size limits the power and voltage
- Lighter
- Cheaper
- More reliable
The Op Amp

The main characteristics

I. Very high open-loop voltage gain
II. Very high input impedance
III. Very low output impedance
The Differential Amplifier

- Basically an op amp is a differential amplifier, i.e. it amplifiers the difference between the two inputs
  - If \( V_2 > V_1 \), \( V_o \) is positive
  - If \( V_2 < V_1 \), \( V_o \) is negative
  - If \( V_2 = V_1 \), \( V_o \) should be zero
Op Amps & Negative Feedback

- Op Amps use n.f.b., some of the output is fed back to the inverting (-) input, this reducing the output of the new amp.

- Effects of n.f.b on the Op Amp
  - Closed loop gain (A) is reduced
  - Wider range of input voltages possible
  - Greater stability, less distortion, increased bandwidth
Bandwidth

- 741 has a unity bandwidth of 1MHz
- Gain Bandwidth product is a constant for a particular Op Amp
- Estimate the gain for a bandwidth of 20kHz from the graph.
The Inverting Amplifier

- Use Kirchhoff’s current law and the Op Amp characteristics
  - very high input impedance
  - very high open-loop gain.
- Voltage Gain is given by:

\[ A = \frac{V_o}{V_i} = -\frac{R_f}{R_i} \]
Inverting Amplifier Practical

- Design and Test an inverting amplifier with a gain of -5 and an input resistance of 2kΩ.
- What is the value of
  - Ri
  - Rf
  - Rb
- Measure the voltage gain at 1kHz
Inverting Amplifier Practical

- Modify the circuit to give an amplifier gain of $-10$ keeping the input resistance of $2k2$.
- Measure the voltage gain at $1k$Hz
Summing Amplifier

- Summing amplifiers add (sum) a number of inputs together.
- Uses the concept of the “virtual earth” and Kirchhoff’s current law to explain the summing point P.
Summing Amplifier

- Common uses include:
  
  i. Audio mixers, to combine a number of inputs (guitars, keyboards, microphones, etc)
  
  ii. Perform mathematical process of addition in analogue computing
The Non-inverting Amplifier

- Negative feedback obtained from potential divider formed by $R_i$ and $R_f$
- Voltage Gain is given by:

$$A = \frac{V_o}{V_i} = 1 + \frac{R_f}{R_i}$$

- Gain only dependant on resistor values
Non-inverting Amplifier Practical

- Design and Test an inverting amplifier with a gain of 23 and an input resistance of 220k.
- What is the value of
  - Ri
  - Rf
- Measure the voltage gain at 1kHz
Voltage Follower

- All of the output is fed back to the inverting input.
- Unity voltage gain amplifier
- The output voltage follows the input (a voltage follower)
- Acts as a buffer amplifier
Circuit Simulation Activity

- You are to use the MultiSim application to capture the circuit designs for:
  1. The inverting amplifier with a gain of:
     a. -5
     b. -10
  2. The non-inverting amplifier with a gain of 23.

- For each circuit, you will need to print out:
  - the circuit diagram,
  - evidence of the gain achieved.
Additional Reading

For more information on Operational Amplifiers go to:
• [www.wiki.computing.hct.ac.uk](http://www.wiki.computing.hct.ac.uk) – the electronics unit 35 page
Simulation

Oscilloscope

Bode Plotter
Oscilloscope

Timebase

Vertical Scale
Bode Plotter – Frequency Response