**Operational Amplifiers Page 28.1**

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| Ideal op-amp key facts ...* The open loop gain is infinity.
* The input resistance is infinity.
* The output resistance is zero.
* The gain bandwidth product is infinity.
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| **Comparator****If V1 > V2, the outpt is high.****If V1 < V2, the output is low.** | **This circuit works because the op amp has a very high open loop gain. This means that tiny differences in the input voltage cause the op amp to saturate low or high.****Saturation occurs when the output is limited by the power supply voltage.** |
| **Non Inverting Amplifier****Gain = 1 + Rf / R1**Input resistance = Infinity / Very High | Non Inverting Amplifier |

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| **Voltage Follower****The voltage gain is ONE.The input resistance is INFINITY.****The current and power gain can be very large.****This circuit is used to drive a high current load without draining current from the input device.** |  |
| **Inverting Amplifier****Gain = - Rf / R1****Don't forget theminus sign!**Input resistance = R1 | Inverting AmplifierThe inverting (-) op amp input is a virtual earth.The op amp has a very high open loop gain so, if the op amp output is a few volts, the input (-) voltage must be a few microvolts. This input voltage is so close to zero it's called a virtual earth. |
| **Summing Amplifier (Adding)**The inverting input is also a virtual earth.This circuit is used to add input signals together. A studio mixer desk is a good example.This circuit can also be used as a digital to analogue converter. Here are some example input resistances for a DAC ...* **Rf = 10k**
* **R4 = 10k**
* **R3 = 20k**
* **R2 = 40k**
* **R1 = 80k**
 | Summing Amplifier (Adding)The input resistance of each input is equal to the input resistor.**Vout = - Rf (V1/R1 + V2/R2 + V3/R3 + V4/R4)** |

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| **Differential Amplifier (Subtracting)**Simple Differential (Subtracting) AmplifierThe input resistance is 2 R1If the two inputs are identical, after subtracting them, nothing is left so the output will be zero. This technique can be used to remove unwanted noise from the inputs. |

**Gain Bandwidth Product**

This is a measure of how well the op-amp works at higher frequencies.

A typical value might be 1 Million Hertz or 1MHz.

There is a very simple mathematical relationship as follows.

In an open loop circuit an input frequency of ...

* 1Hz will be amplified 1 million times.
* 10Hz will be amplified 100 000 times.
* 100Hz will be amplified 10 000 times.
* 1000Hz will be amplified 1000 times.
* 10 000Hz will be amplified 100 times.
* 100 000Hz will be amplified 10 times.
* 1MHz will be amplified 1 times.

Input Frequency x Gain = 1Million.

So to calculate the gain at 500 Hz.

500 x GAIN = 1 Million.

GAIN = 1000000 / 500 = 2000

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