INTRODUCTION TO OPAMPS

July Presentation Summary

WONDERFUL, SOPHISTICATED, VERY USEFUL, COMPACT, CHEAP DEVICES

ALL YOU NEED TO KNOW IN ~ 60 MINUTES

(There may be a test at the end and punishment for inattention)

"A modern OPAMP is a neatly packaged, rather complicated and quite sophisticated piece of electronic circuitry.

However," .... "you don't need to know" .... "impressive things" ,...............

(if you want to know more, you will need to attend MELBPC uP Group's Wed 9 July 2014 meeting)

No need to take many notes – on 10 july, this presentation will be published on

https://groups.google.com/forum/?hl=en#!forum/microcontrollergroup

John Macey

Modern OPAMPS are neatly packaged, rather complicated and quite sophisticated pieces of electronic circuitry. They are readily available, compact and quite cheap. (eg An **LM324** general purpose quad opamp, <$1 from RS)

You don't need to know a lot about electronics to use them to do quite impressive things.

For most common applications (with modest voltages, modest currents and frequencies less than ~1 MHz) you can regard a typical OPAMP as a **"black box"**.

Generally, you don't need to know what's inside the "black box".

In (**Fig1**) the **"black box"** has 2 power supply connections,1 output (label it "**Vout**") and 2 inputs (label them as **"inverting input (V-)"** and **"non-inverting input (V+)"**

The key useful characteristics of OPAMPS are that :-

1) **They have very high input impedances** ie practically, ***no current flows into the inputs***

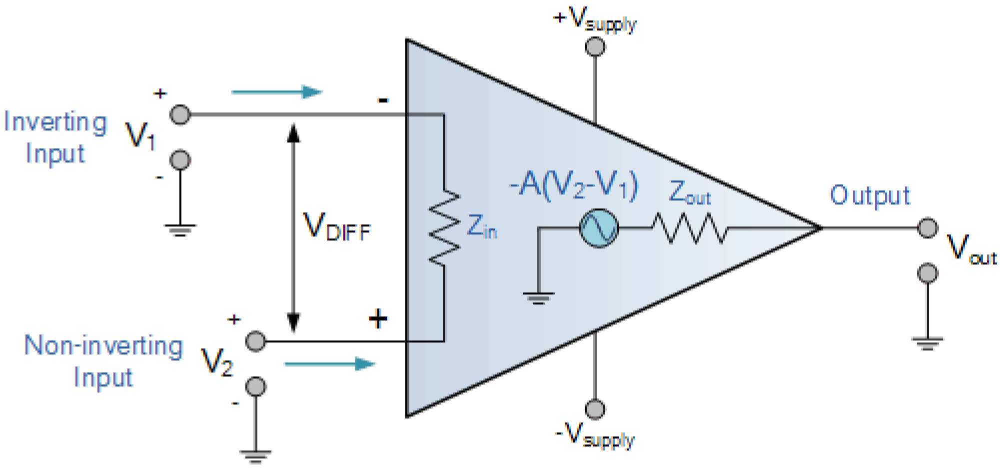
2) **OPAMPS amplify the *difference voltage*** between the 2 inputs**, Vdiff**

3) **Vout = A * Vdiff** where A is the voltage gain, a big number (eg A >25,000 for an **LM324**)

4) Low output impedance **"Zout"**, (eg. about 100 to 200 ohms for an **LM324**)

note that - High values of Vout are limited by the available supply voltages
You won't get several thousand volts output with a 1V Vdiff input! – you will get between ~ +/- Vsupply

Fig1



Comparators

While these chracteristics are not very (immediately) useful as an amplifier, we can immediately make use of them as a ***comparator*** to produce a binary output result, ("1" or "0"), ("Hi" or "Lo",) depending on whether V+ is more or less positive than V-.

A comparator can be very sensitive, switching with just a few millivolts input voltage difference (**Vdiff**).
Or you can add **hysteresis** (simply, with more resistors)   (see the References at the end of this presentation)
to increase the switching differential (making it less sensitive)

Any OPAMP can do this, but some are specially designed to do it well and have some useful additional features.

Examples -   **LM339** a general purpose quad comparator (a DIP chip costing less than is $1 from RS).

- **LT1719** a fast/wideband comparitor with wide input and output voltage ranges (a SOIC ~$5)

Voltage Feedback Amplifiers (dual power supply)

Suppose that we power an opamp with +5V and -5V relative to ground.

Now we connect the **V+** (**"non-inverting"**) input to ground and apply an input signal "**Vin** through a resistor "**Rin**" to the **V-** (**"inverting"**) input which also has a "**feedback**" resistor "**Rf**" connected to the output.

This is an "**inverting amplifier**" configuration (**fig 2**) with a negative gain value "**G**"   (and input impedance Rin)

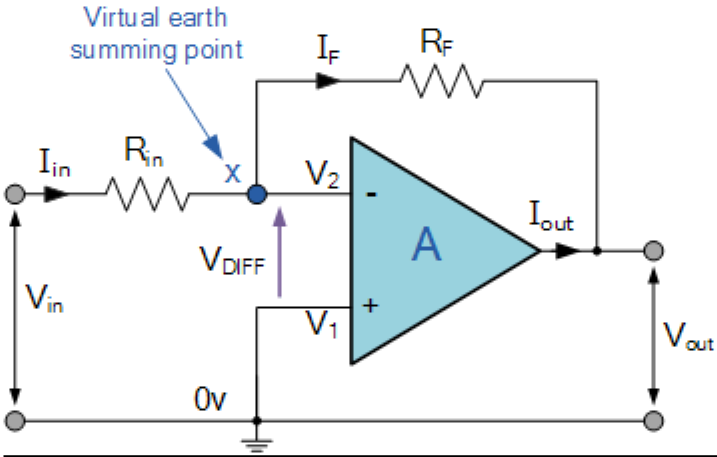
This **feedback** circuit behaves in such a way as to force V- to equal V+ ie. **Vdiff = zero**.

{   So **if** G = Vout/Vin, and V- = V+ = 0 and the current into the V- pin = zero)   }
{   }
{   Vin/Rin = - Vout/Rf ,   so G = (Vout/Vin) = - (Rf/Rin)   }

Inverting Amp   **G = Vout/Vin = - (Rf/Rin)**   **or**   **Vout = - Vin*(Rf/Rin)**

note that - the overall gain depends only on the feedback network resistor values.

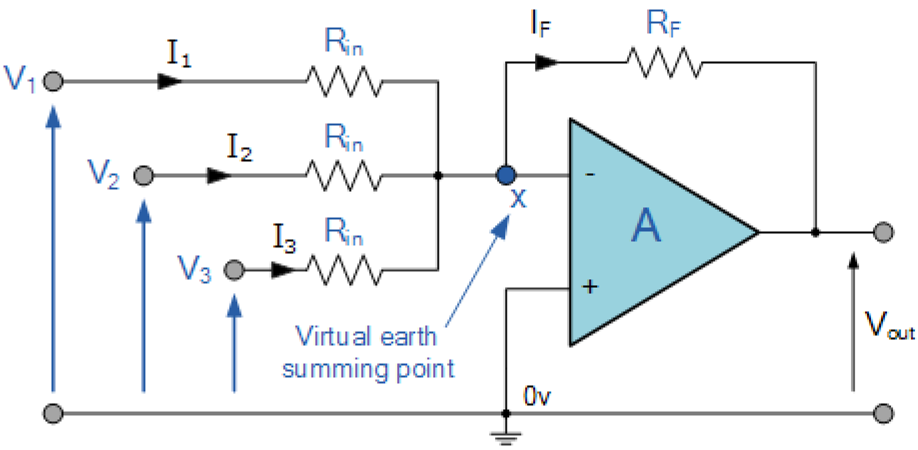
Fig2



If we have additional inputs connected to an inverting input via their series resistor R2, R3, etc we can make an "**inverting summing amplifier**"   (**Fig3**)

The output **Vout = - (G1*Vin1 + G2*Vin2 + etc)**   **where G1 = (Rf/R1) , G2 = (Rf/R2), etc**

Fig3



Similarly, we can configure the circuit to produce a **non-inverting summing amplifier**
or **an inverting or a non-inverting "difference amplifier"**

(see references for a .pdf file with many useful OPAMP configuration variants)

A "**non-inverting amplifier**" configuration (**Fig 4**) has a positive gain value (**G = Vout/Vin**)

(and a very high input impedance – a useful characteristic in some applicatins)

It's **V-** input is connected to an R2, Rf **feedback** network and the signal to be amplified (**Vin**) goes to the **V+** input.

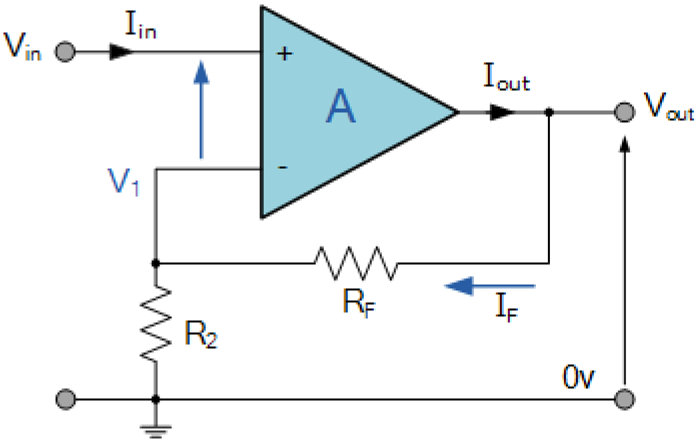
Again, the circuit behaves in such a way as to force the difference between the V- and V+ inputs to zero.

Then for zero current into V- and for V- = V+, you can derive the non-inverting amp gain as:-

Non-Inverting Amp

G = 1 + (Rf/R1)   **Vout = Vin*(1+Rf/R2)**

Fig4



Voltage Feedback Amplifiers (single power supply)

Frequently, **only a single voltage Vcc** power supply (say +5V and ground) **is available** to power circuits.

If an OPAMP is to be operated with a single supply, it is necessary to also create a

"virtual ground" at half the supply voltage (+2.5V in the above case).

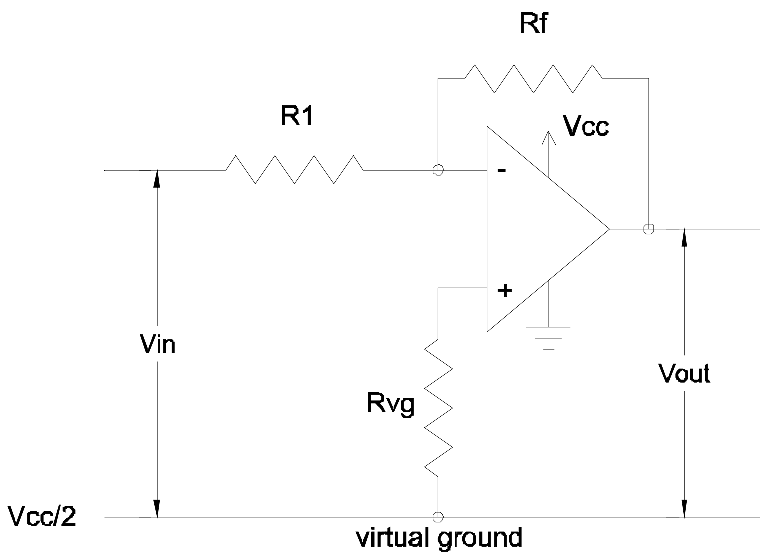
Then all inputs and outputs are referred to this virtual ground.

You can think of it as the whole device behaving as if it were floating 2.5V above true ground

Signal connections that would have been connected to ground in a dual-supply configuration are connected to the virtual ground in the single supply configuration.

(**Fig 4**) shows an **inverting amp** example. **Vout = - Vin*Rf/R1 (measured from Vcc/2)**

Fig4



Rvg should be (about) equal to the parallel resistance of all the resistors connected to the other input. ie in the case of the inverting amplifier **Fig4** **Rvg = R1//Rf = (R1*Rf)/(R1 + Rf)**.

Ref: Good articles on many electronic topics. This one on Op Amps

http://www.electronics-tutorials.ws/opamp/opamp_1.html

Ref: Another useful reference article - (Google it) **AN-31 Op Amp Circuit Collection**