Integrated Circuit

Op amps — Show circ diagram @ AD741

Speecsheet New — list of useful ones H/H

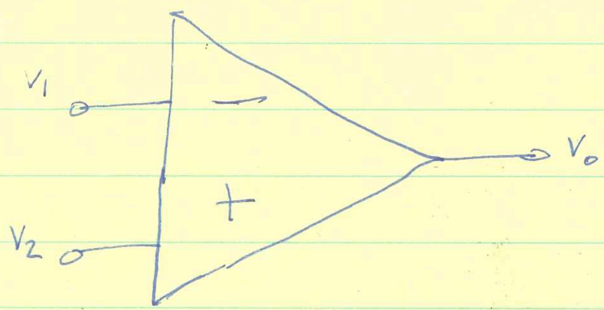
Useful for analog electronics. Picture

Pinout

INA 10?

AD624 INA110

Ideal

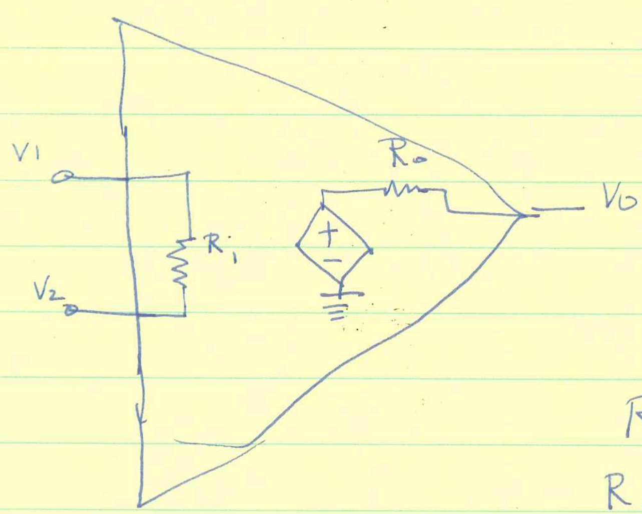


$$V_o = A\,V_d = A(V_2 - V_1) \qquad A \to \infty \text{ ideal}$$

A large (real) 10^5–10^8

Current into terminals 1, 2 = 0.

Real

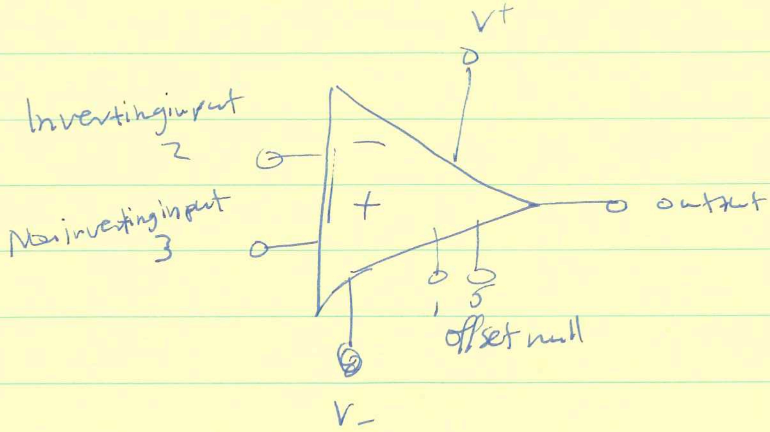


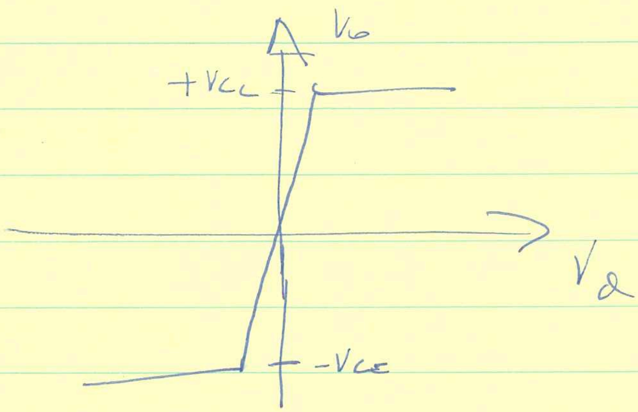
$R_i = 10^5$ to $10^{13}\ \Omega$ — ∞ ideal

$R_o = 10$ to $100\ \Omega$ — 0 ideal

Need power supply → V_{cc}^+ V_{cc}^-

Power supply





Useful circuits

Buffer.
Inverting amp
Noninverting amp
Adder
Subtractor

DAC
Instamp. (CMRR) dB
Curr to voltage converter

In all analysis

$i = 0$ inputs

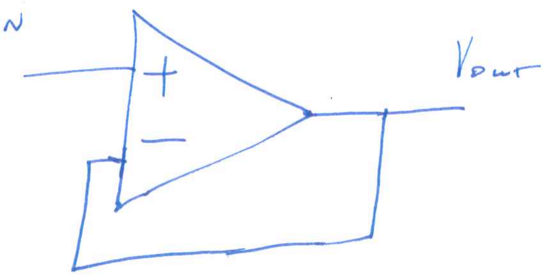
Gain $\to \infty$ but use feedback.
Output adjusts itself so that
$V_2 - V_1 = 0$

General idea : ∞ gain amplifier very useful.
Generally can be made into many different circuits.

Buffer

Voltage Follower

Unity gain ~~be~~ amplifier

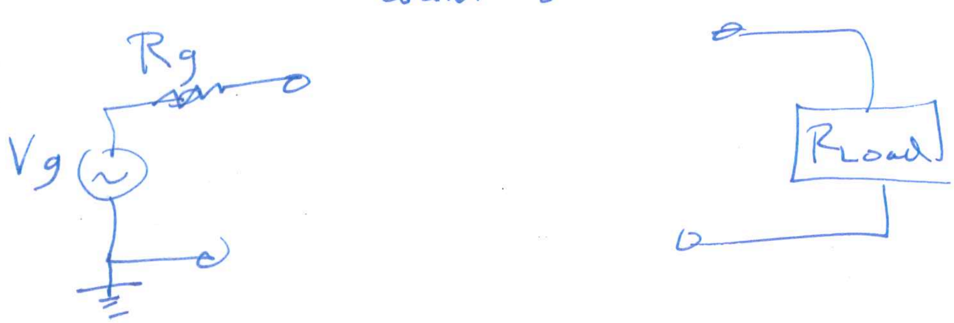


$V_{OUT} = V_{IN}$

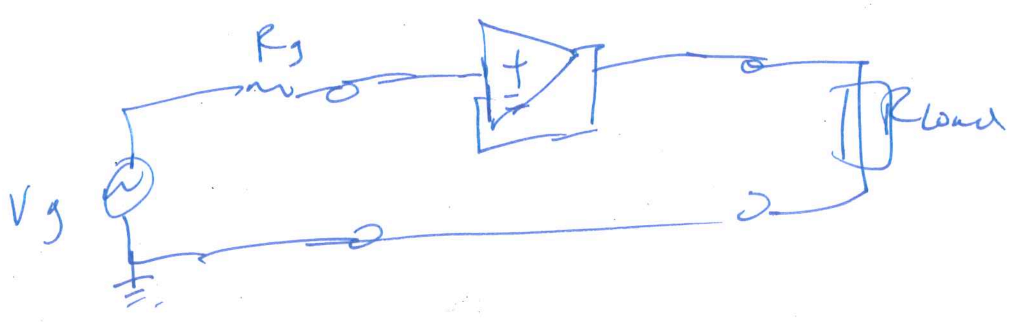
<u>why</u>? won't load circuit.

Eg.

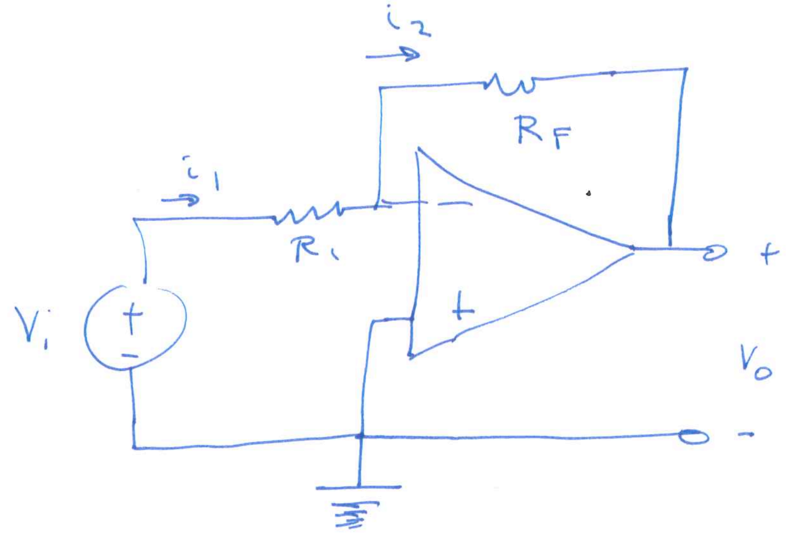
want V_g @ R_{load} even if $R_{load} \sim R_g$



Then.



INVERTING AMP



$i_1 = i_2$

$$\Rightarrow \frac{V_i - V_1}{R_1} = \frac{V_1 - V_o}{R_F}$$

$V_1 = V_2 = 0$

$$\Rightarrow \frac{V_i}{R_1} = \frac{-V_o}{R_F}$$

$$= \boxed{\frac{V_o}{V_i} = -\frac{R_F}{R_1}}$$

What is input resistance?

R_1

e.g. $R_F = R_1$

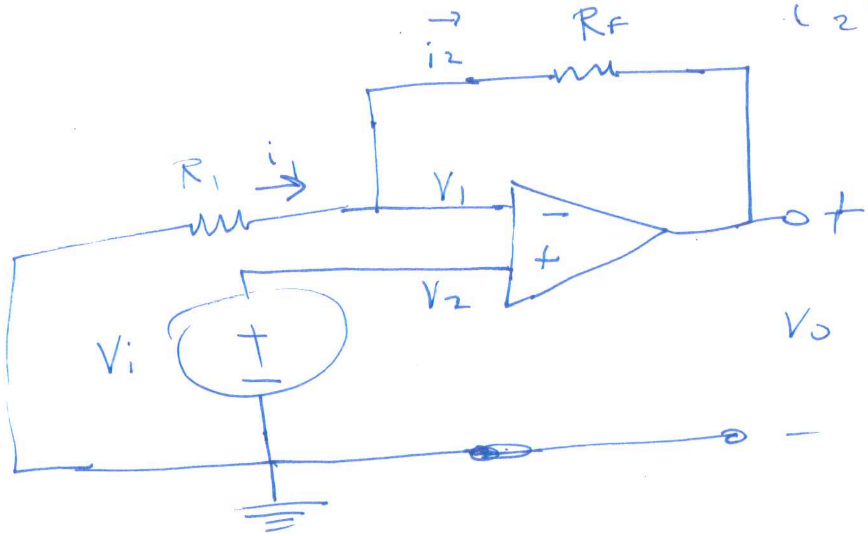
$\frac{V_o}{V_i} = -1$ INVERTER

$V_i = i_1 R_1$

Noninverting amp

$v_o - V_i = i_2 R_F$

$i_2 = i_1$



$i_1 = i_2 = 0 \Rightarrow \frac{0 - v_1}{R_1} = \frac{V_1 - V_o}{R_F}$

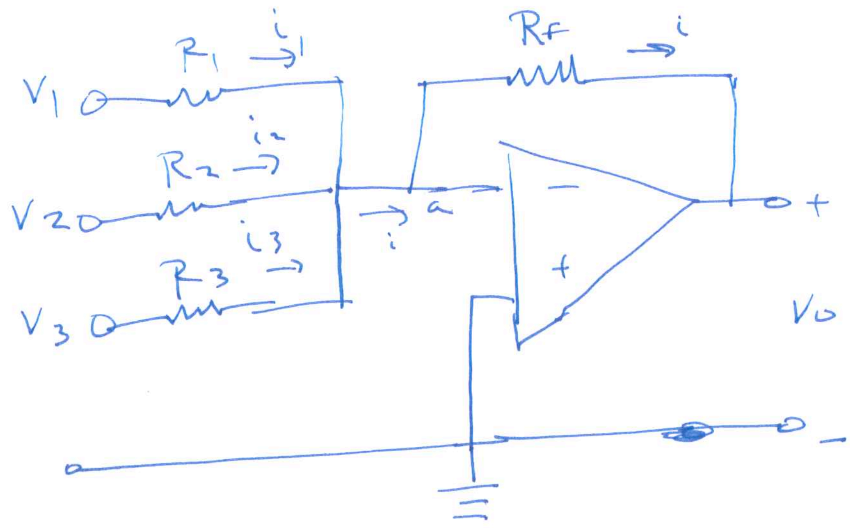
$V_1 = V_2 = V_i$

$\Rightarrow \frac{-V_i}{R_1} = \frac{V_i - V_o}{R_F}$

$\Rightarrow V_o = \left(1 + \frac{R_F}{R_1}\right) V_i$

$R_F = 0 \Rightarrow$ voltage follower
$V_o = V_i$ unity gain ~~buffer~~ amplifier
"buffer"

Adder



$i = i_1 + i_2 + i_3$

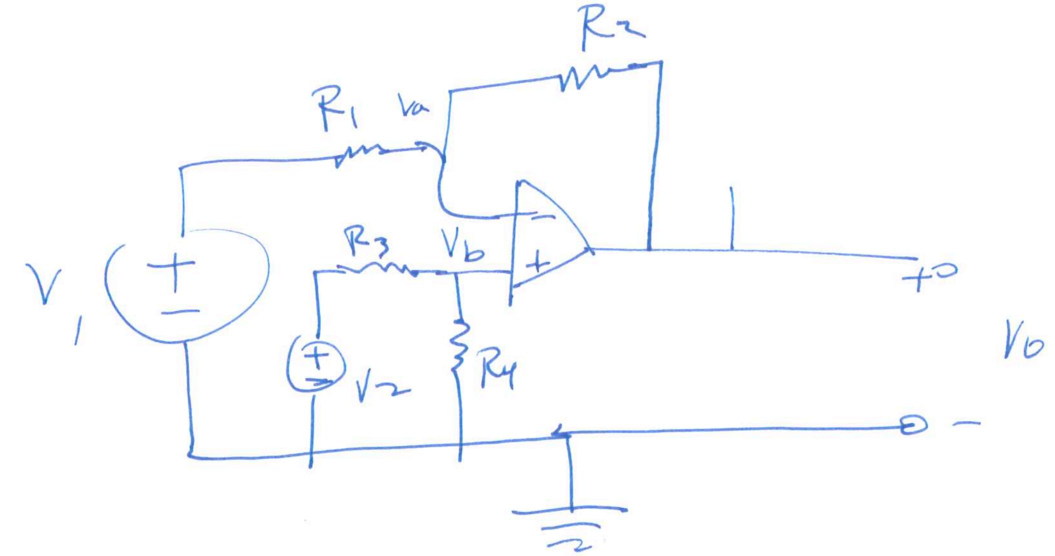
Node a @ 0.

$\Rightarrow i_1 = \frac{V_1}{R_1} \qquad i_2 = \frac{V_2}{R_2} \qquad i_3 = \frac{V_3}{R_3}$

$i = \frac{-V_o}{R_F}$

$\Rightarrow V_o = -\left(\frac{R_F}{R_1} V_1 + \frac{R_F}{R_2} V_2 + \frac{R_F}{R_3} V_3 \right)$

Subtractor (Differential amplifier)



$$\frac{V_2 - V_b}{R_3} = \frac{V_b}{R_4} \iff V_b = \frac{R_4}{R_3 + R_4} V_2$$

$$\frac{V_1 - V_a}{R_1} = \frac{V_a - V_o}{R_2} \iff V_o = \left(\frac{R_2}{R_1} + 1\right) V_a - \frac{R_2}{R_1} V_1$$

But $V_a = V_b$

$$\Rightarrow V_o = \left(\frac{R_2}{R_1} + 1\right) \frac{R_4}{R_3 + R_4} V_2 - \frac{R_2}{R_1} V_1$$

$$\Rightarrow V_o = \frac{R_2 (1 + R_1/R_2)}{R_1 (1 + R_3/R_4)} V_2 - \frac{R_2}{R_1} V_1$$

If $\frac{R_1}{R_2} = \frac{R_3}{R_4} \Rightarrow V_o = \frac{R_2}{R_1}(V_2 - V_1)$

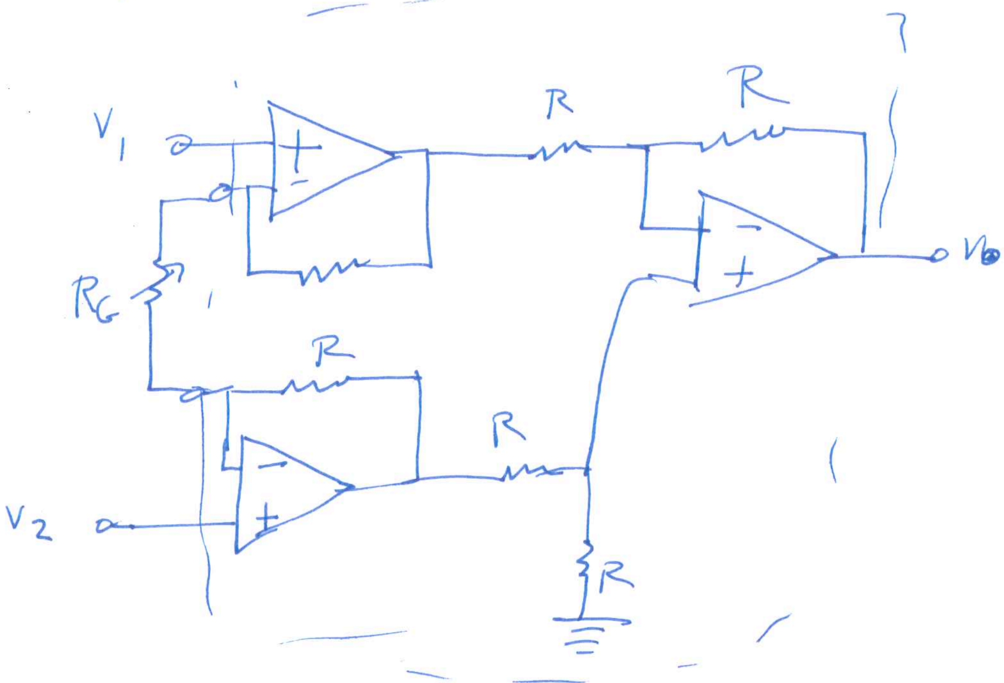
If $R_2 = R_1$ $R_3 = R_4$

$\Rightarrow V_o = V_2 - V_1$

Differential Amp.

Show data sheet. (AD

INST Amp



$$V_o = \left(1+\frac{2R}{R_G}\right)(V_2 - V_1)$$

Features

1) Voltage gain set by one resistor.

2) V_1, V_2 high input impedance.

3) Good CMRR. (dB)

130dB AD624

0.1 µV/V

140dB

~150dB

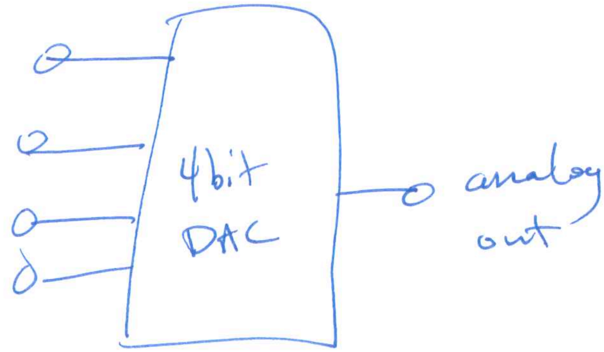
Show data sheet AD624

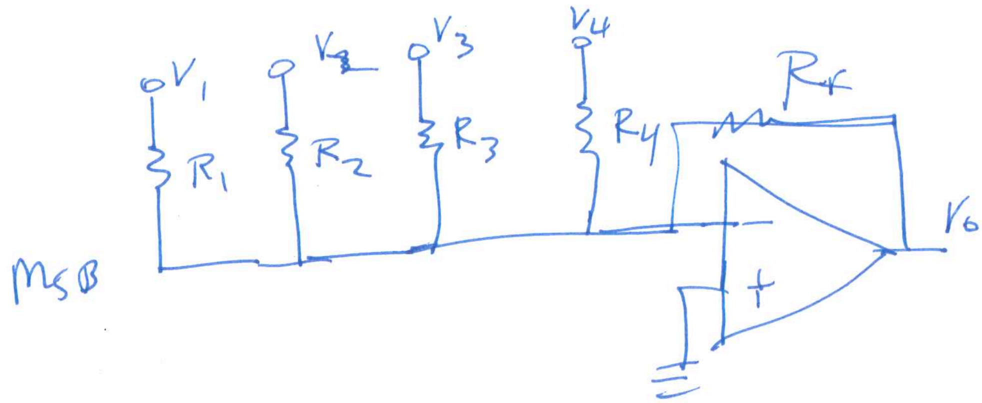
1 NA Burr Brown 110

AD741

~120dB

~~Add~~ DAC





$$-V_0 = \frac{R_F}{R_1}V_1 + \frac{R_F}{R_2}V_2 + \frac{R_F}{R_3}V_3 + \frac{R_F}{R_4}V_4$$

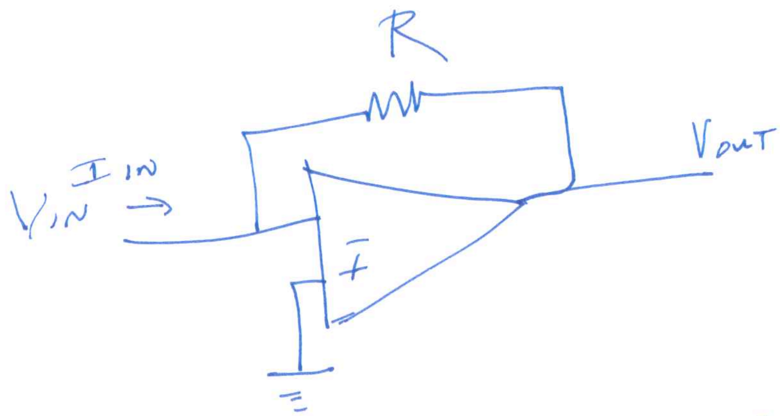
2^4 different possible outputs V_0

depending on bits 1-4

Show datasheet.

ADC is opposite, ~~more~~ harder to describe.

Currant to voltage converter



$$V_{out} = R\, I_{IN}$$