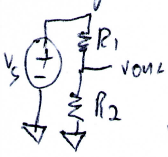
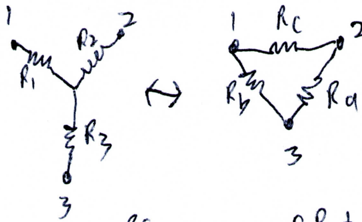
Voltage Divider :

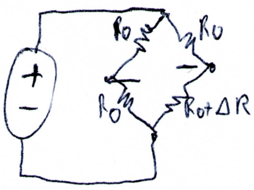


$V_{out} = \left(\frac{V_S}{R_1+R_2}\right) \cdot R_2$

$V_0 = \frac{V_S - V_G}{R_1+R_2} \cdot R_2 + V_G$



$R_1 = \frac{R_b R_C}{R_a+R_b+R_C}$ $R_a = \frac{R_1R_2 + R_2R_3 + R_1R_3}{R_1}$



iff $\frac{\Delta R}{R} \ll 1 \Rightarrow V_{out} = \frac{1}{4} \cdot \frac{\Delta R}{R} \cdot V_{in}$

plug in — smallest meas V

$\frac{\Delta R}{R} = \frac{V_{out}}{(?)} \rightarrow x \cdot 10^{-x}$ V resol.

resistors in parallel $i = i \cdot \frac{R_{eq}}{R_i}$

$\left(\frac{1}{R_1} + \frac{1}{R_2} \cdots \frac{1}{R_n}\right)^{-1}$ same voltage — current divider

resistors in series

$R_1 + R_2 + R_3 \ldots R_n$ same current

$R = \frac{l}{\sigma A} = \rho \frac{l}{A}$

ρ = resistivity

σ = conductivity

$P = vi = \frac{v^2}{R} = (i^2)R$

p>0 = absorb

p<0 = supply

max power when $R_S = R_L$

siemen $= \frac{1}{\Omega}$ = conductivity   V = IR

$\rho = \frac{1}{\sigma} = \Omega \cdot m$ = resistivity

cannot have voltage src in parallel

cannot have current src in series

$I_D = I_S\left(e^{\frac{V_D}{V_{th}}} - 1\right)$ $I_S \cdot 10^{\frac{V_D}{60mV}}$

$\begin{cases} -I_S & V_D < -100mV \\ 0 & V_D = 0 \\ I_S \cdot e^{\frac{V_D}{V_{th}}} & V_D > 100mV \end{cases}$ $I_S \cdot e^{\frac{V_D}{0.026V}}$

60mV − $I_S \cdot 10^x$

26mV − $I_S \cdot e^x$

Thevenin/Norton

V = IR

1. use nodal to get Vab
2. solve for current by sc(a,b)
3. get Req

a) oc = zero current = no V drop

Superposition

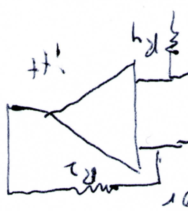
- one source at a time
- sc voltages, oc currents

add results for total current

Nodal Analysis

1. find extraordinary
2. pick ground
3. label currents
4. KCL at each node
5. plug in $\frac{v}{R}$ instead i
6. write as $[G][v] = i$

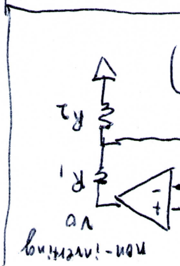
Subtractor



$V_{out} = \frac{-R_2}{R_1} V_1 + \left(\frac{R_1+R_2}{R_2}\right)\left(\frac{R_4}{R_3+R_4}\right) V_2$

iff $R_1 = R_3,\ R_2 = R_4 \Rightarrow V_{out} = \frac{R_2}{R_1}(V_2 - V_1)$

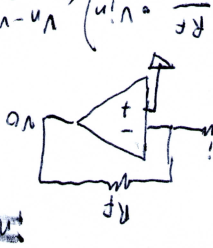
non-inverting



$V_0 = V_{in}\left(1 + \frac{R_1}{R_2}\right)$

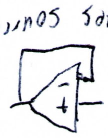
$i_n = i_p = 0,\ V_n = V_p$

inverting



$V_0 = \left(-\frac{R_f}{R_i} \cdot V_{in}\right)$ V_n - virtual gnd — can duplicate to $V_2 \cdot \frac{-R_f}{R_2}$

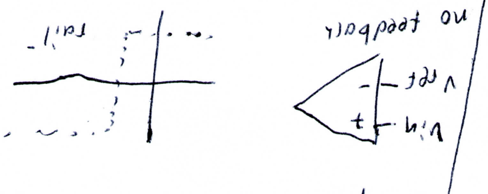
Buffer



isolates source/load

transfer voltage with no drop

comparator



no feedback

open loop

slope = gain