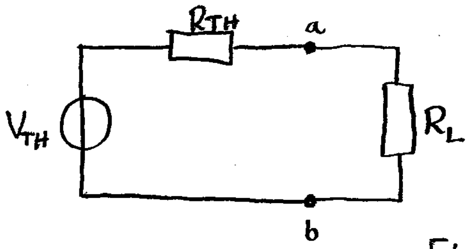
Inbyggd Elektronik 2018-04-10 #6



Power consumed in the load R_L?

$$P = U \cdot I = V_{TH} \frac{R_L}{R_{TH}+R_L} \frac{V_{TH}}{R_{TH}+R_L} = \frac{R_L}{(R_{TH}+R_L)^2} V_{TH}^2$$

Find P_{max} $$\frac{dP}{dR_L} = \left\{ \frac{d}{dR_L} \frac{1}{(R_{TH}+R_L)^2} = \frac{-2}{(R_{TH}+R_L)^3} \right\} =$$

$$= \left(\frac{1}{(R_{TH}+R_L)^2} - \frac{2R_L}{(R_{TH}+R_L)^3} \right) V_{TH}^2 = 0$$

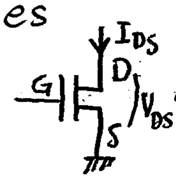
$$\Rightarrow 1 - \frac{2R_L}{R_{TH}+R_L} = 0 \Rightarrow R_{TH} + R_L - 2R_L = 0 \Rightarrow \boxed{R_L = R_{TH}}$$

Maximum power is consumed in the load when $R_L = R_{TH}$

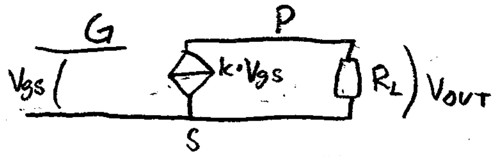
$$P_{MAX} = \frac{R_{TH}}{(2R_{TH})^2} V_{TH} = \frac{V_{TH}^3}{4R_{TH}}$$

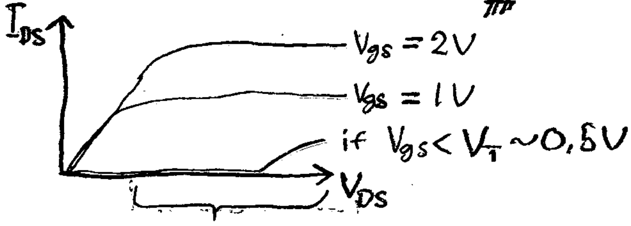
Dependent Sources

Ex: Transistor



can be modeled



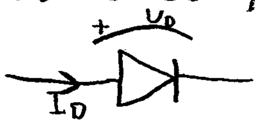


Transistor is a voltage controlled current source

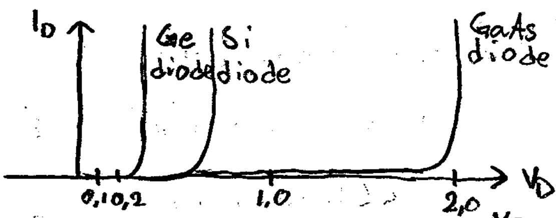
$V_{OUT} = k \cdot V_{gs} \cdot R_L \Rightarrow \frac{V_{OUT}}{V_{in}} = kR_L$

if $k \cdot R_L > 1$ then amplification

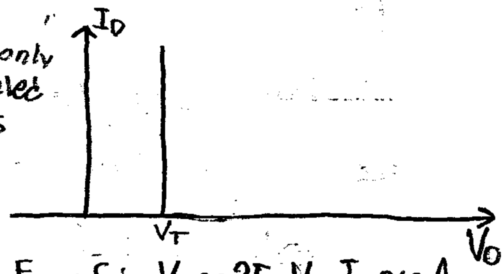
Active component: Diode



Non-linear characteristics



Commonly modeled as



Detailed analysis gives $I_D = I_0(e^{\frac{V_D}{V_0}} - 1)$ For Si: $V_0 \sim 25mV$ $I_0 \sim nA$

For $V_D < V_T$ $I_D = 0$

$V_D = V_T$ Ideal voltage source

$V_D > V_T$ not possible

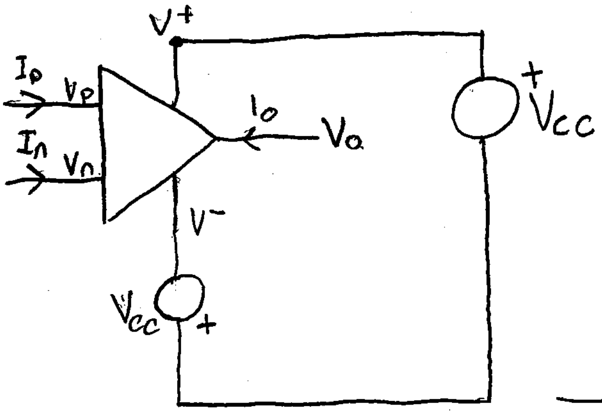
if $V_D > V_T$ is applied and no resistor limits the current the power in the diode will heat it up and eventually destroy it. Typically $I_D < 20mA$

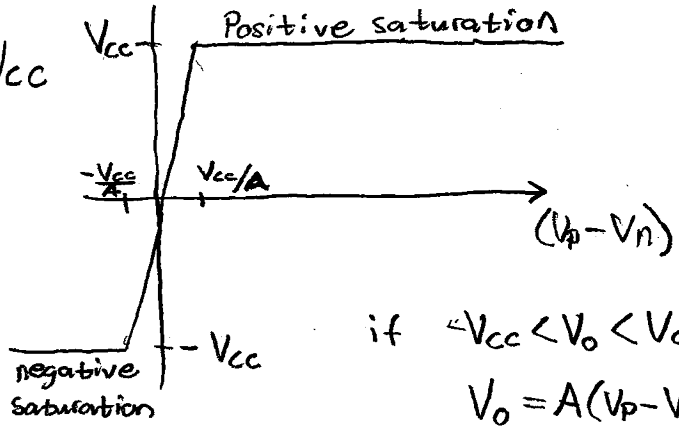
For Si/Ge energy is converted to heat

For Light Emitting Diodes (LED) part of the energy is converted to light.

Operational Amplifier

Basic building block to build analog circuits eg. amplifier.

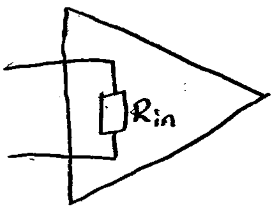




if $-V_{cc} < V_o < V_{cc}$

$V_o = A(V_p - V_n)$

A is amplification



Typically $A > 10000$ and $V_{cc} = 15V$

$\Rightarrow$ Linear region if $V_p - V_n < 1{,}5mV$

Input resistance $R_{in} \geq 10M\Omega$

$\Rightarrow \boxed{I_p = I_n = 0}$

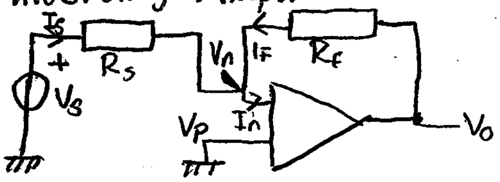
In linear region $\boxed{V_p = V_n}$!!!

$I_p + I_n + I_o + I_{V+} + I_{V-} = 0$

so i_o can be large although $i_p = i_n = 0$!

We assure that the op-amp is in the linear region by using negative feedback i.e. connecting a resistor R_f between output and the inverting node (-)

Ex. Inverting-Amplifier



Ideal op-amp $\boxed{V_n = V_p}$ $\boxed{i_n = i_p = 0}$

KCL at node V_n: $\dfrac{V_s - 0}{R_s} + \dfrac{V_o - 0}{R_f} = 0$

$\Rightarrow V_o = -\frac{R_f}{R_s} V_s$ V_o is proportional to V_s and amplification is $-\frac{R_f}{R_s}$

If $V_{cc} = 15V$ and $\frac{R_f}{R_s} = 10 \Rightarrow V_s < 1{,}5V$