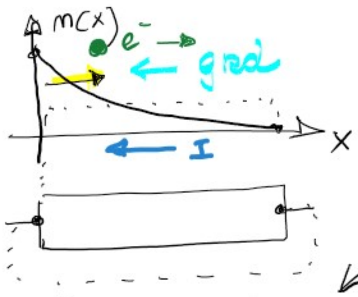
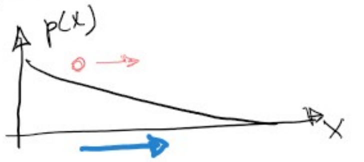
Correnti di diffusione e giunzione pn

martedì 17 marzo 2020 09:30

CORRENTE DI DIFFUSIONE





coeffic. di diffusione elettroni $D_n = 32\ cm^2/s$

$$\vec{J}_{n\,diff} = (-q)\, D_n \left[-grad\ n(x,y,z)\right]$$

$$\vec{J}_{p\,diff} = q\, D_p \left[-grad\ p(x,y,z)\right]$$

coeff. di diff. delle lacune $D_p = 12\ cm^2/s$

$$\vec{J}_{TOT\,diff} = \vec{J}_{n\,diff} + \vec{J}_{p\,diff} =$$

$$= (-q)\, D_n \left[-grad\ n(x,y,z)\right] + q\, D_p \left[-grad\ p(x,y,z)\right]$$

$$D_n = \frac{k_B T}{q}\mu_n$$

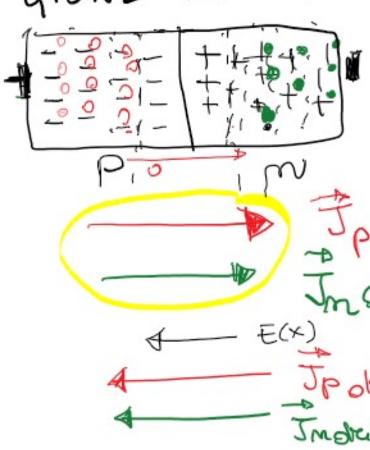
$$D_p = \frac{k_B T}{q}\mu_p$$

RELAZ. DI EINSTEIN

$k_B T \rightarrow$ energia termica

$V_{th} = \dfrac{k_B T}{q} \rightarrow$ tensione Termica $\rightarrow 25\,mV$

GIUNZIONE P-N



$N_A > N_D$

$\vec{J}_{p\,diff}$, $\vec{J}_{n\,diff}$] MAGGIORIT.

$E(x)$

$\vec{J}_{p\,drift}$, $\vec{J}_{n\,drift}$] MINORITARI

EQUILIBRIO

$|\vec{J}_{p\,diff}| = |\vec{J}_{p\,drift}|$

$|\vec{J}_{n\,diff}| = |\vec{J}_{n\,drift}|$

BILANCIO DETTAGLIATO

TENSIONE DI BUILT IN

POLARIZZAZIONE INVERSA

TENSIONE DI BUILT IN

POLARIZZAZIONE INVERSA

$I < I_S$ ← corrente di drift

aumenta la zona di carica spaziale

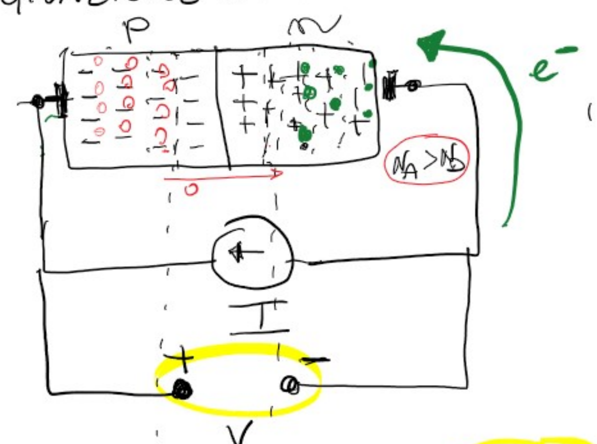
↓

AUMENTA LA BARRIERA DI POTENZIALE

Breakdown della giunzione

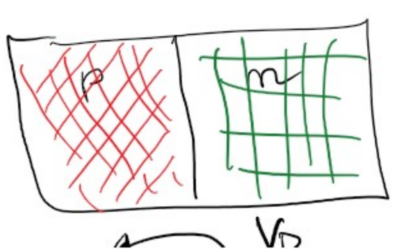
- EFFETTO ZENER $V_{REV} \lesssim 5V$
- EFFETTO VALANGA $V_{REV} \geq 7V$

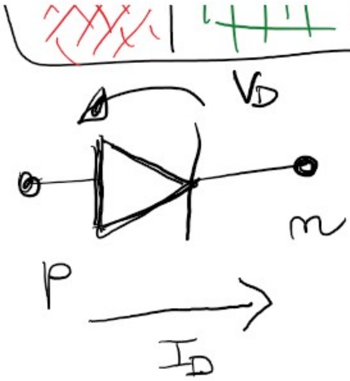
GIUNZIONE PN IN POLARIZZAZIONE DIRETTA



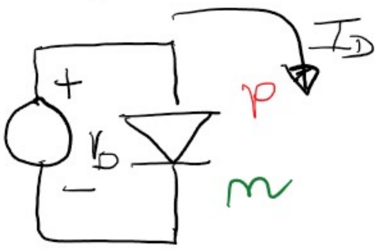
n_{p0} conc. di elettroni minoritari in zona p all'equilib

p_{n0} conc. di lacune minoritarie in zona n all'equilibr.

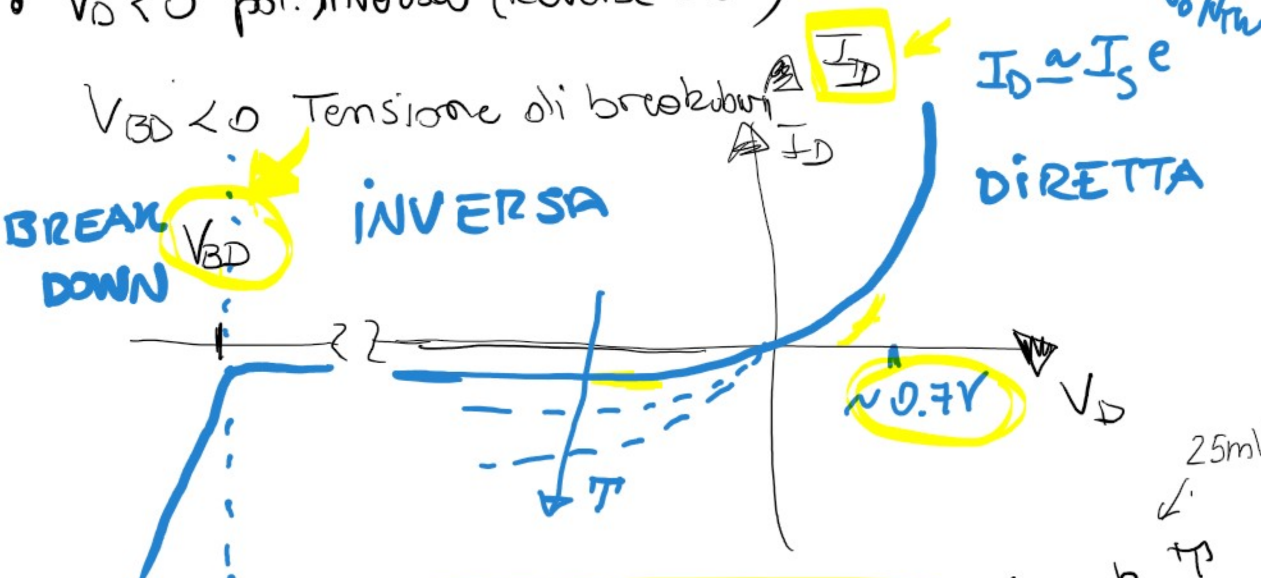




CARATTERISTICA IV DEL DIODO A GIUNZIONE



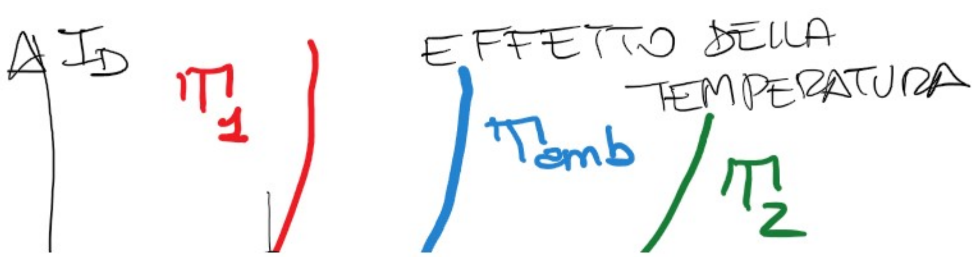
- $V_D > 0$ pol. diretta (Forward bias)
- $V_D < 0$ pol. inversa (Reverse bias)

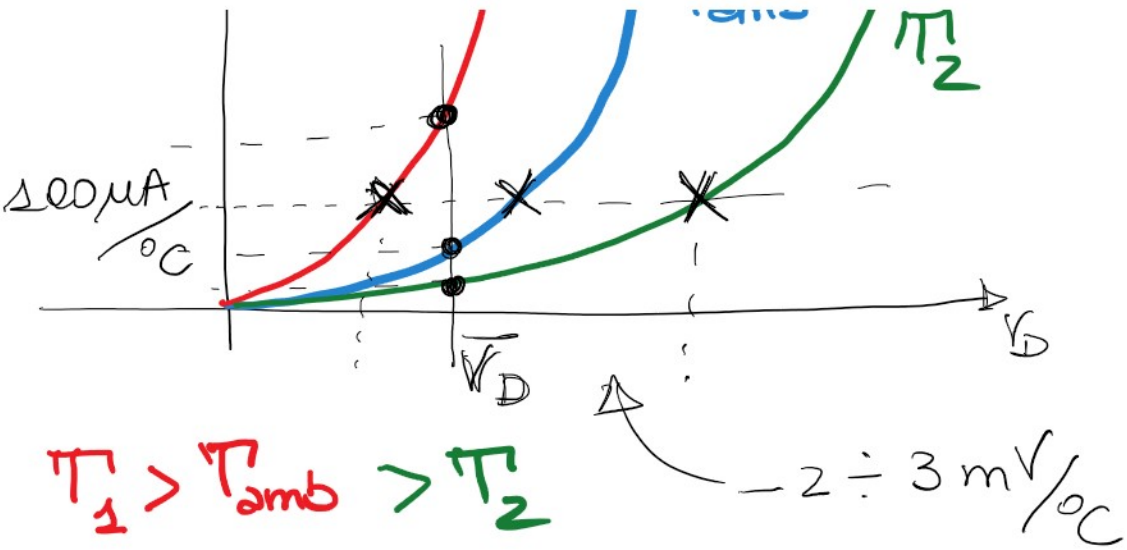


$$I_D = I_S \left[\exp\left(\frac{V_D}{V_{Th}}\right) - 1 \right]$$

$$V_{Th} = \frac{k_B T}{q}$$

I_S : corrente di saturazione inversa





$T_1 > T_{amb} > T_2$

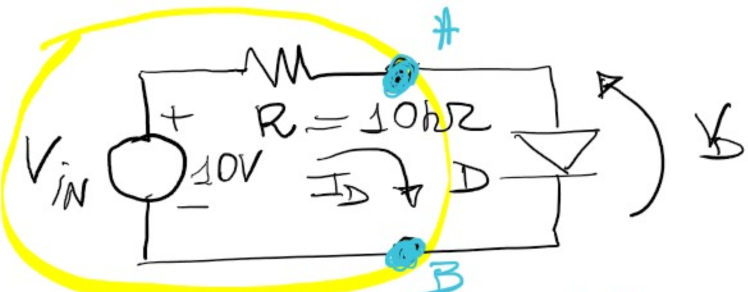
DISSIPAZ. POTENZA

$P \simeq 0{,}7V * I_D$ pol. diretta

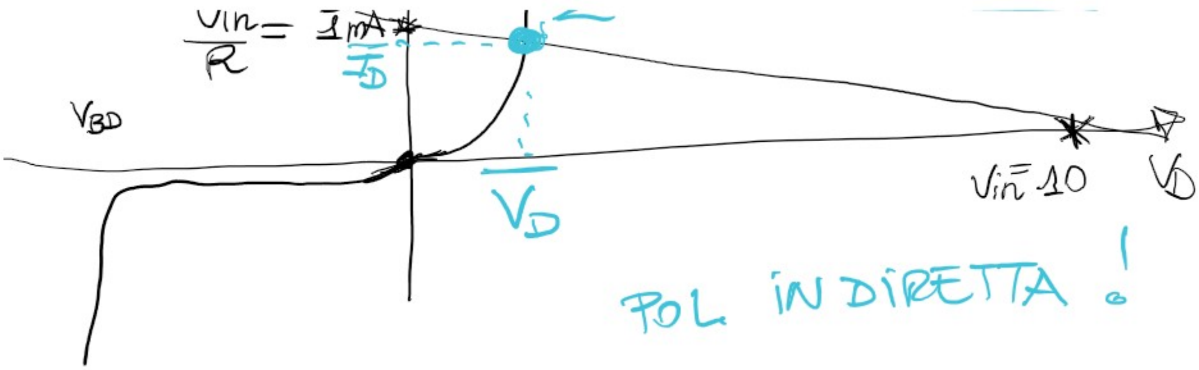
$P \simeq 0\ W$ pol. inversa

$P \simeq |V_{BD}|\ |I_D|$ Breakdown

ANALISI DI CIRCUITI CON DIODI, MODELLIZZAZIONE DEL DIODO



* METODO GRAFICO
* METODO ANALITICO
* SEMPLIFICAZIONE MEDIANTE MODELLI



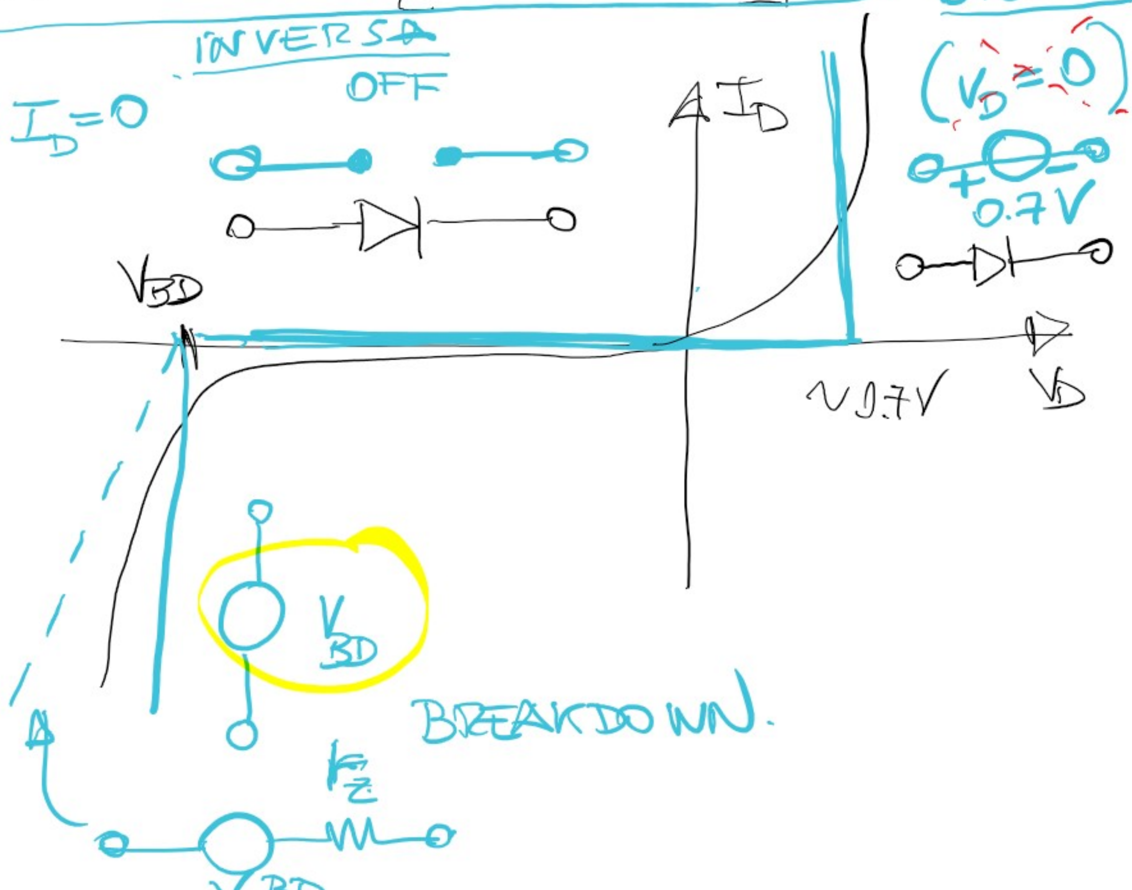
POL. IN DIRETTA!

$$\begin{cases} I_D = I_S \left[\exp\left(\frac{V_D}{V_{Th}}\right) - 1 \right] \\ V_D = V_{IN} - I_D R \end{cases}$$

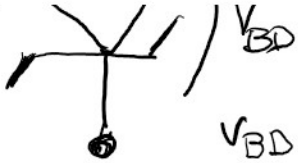
EQ. TRASCENDENTE

$$V_D = V_{IN} - I_S \left[\exp\left(\frac{V_D}{V_{Th}}\right) - 1 \right] R$$

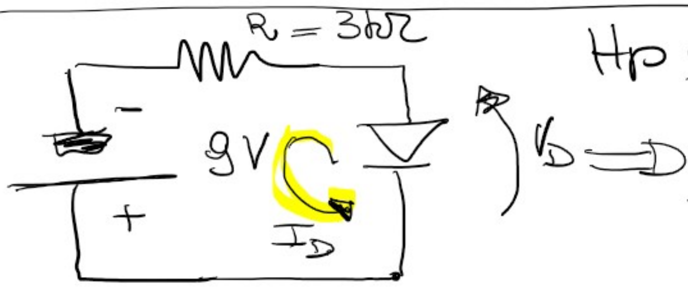
$\Rightarrow I_D, V_D$.



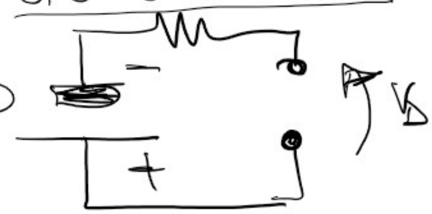
DIODI ZENER



$V_{BD} < 0$.



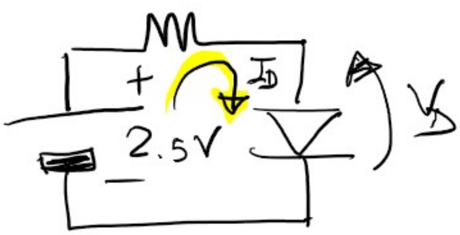
Hp diodo in inversa



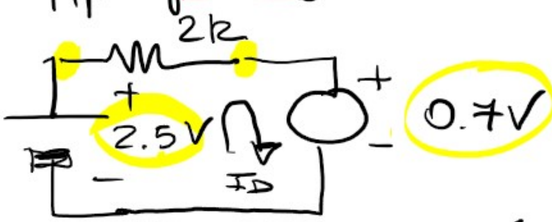
$I_D = 0$

→ $V_D = -9V$

✓ ok è in inversa.



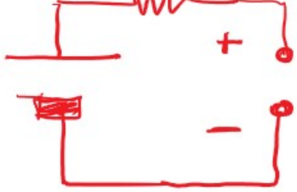
Hp pol. diretta



$I_D > 0$! ok diodo in diretta

$$I_D = \frac{2.5V - 0.7V}{2k\Omega} = 0.9\,mA$$

Hp. pol. inversa



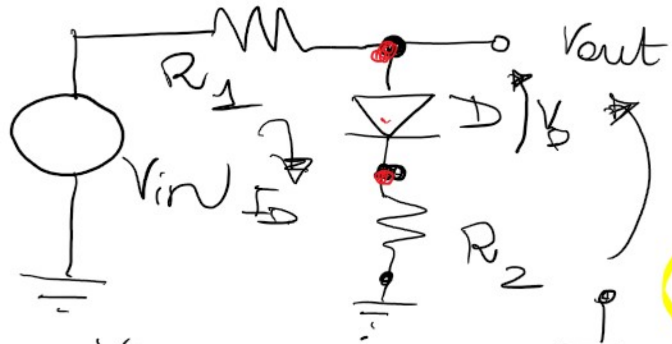
$V_D = +2.5V$ ASSURDO !

~~No $\{ V_D = 2.5V,\ I_D = 0$~~

⇓ pol. DIRETTA

$= 2 I_D = 0$

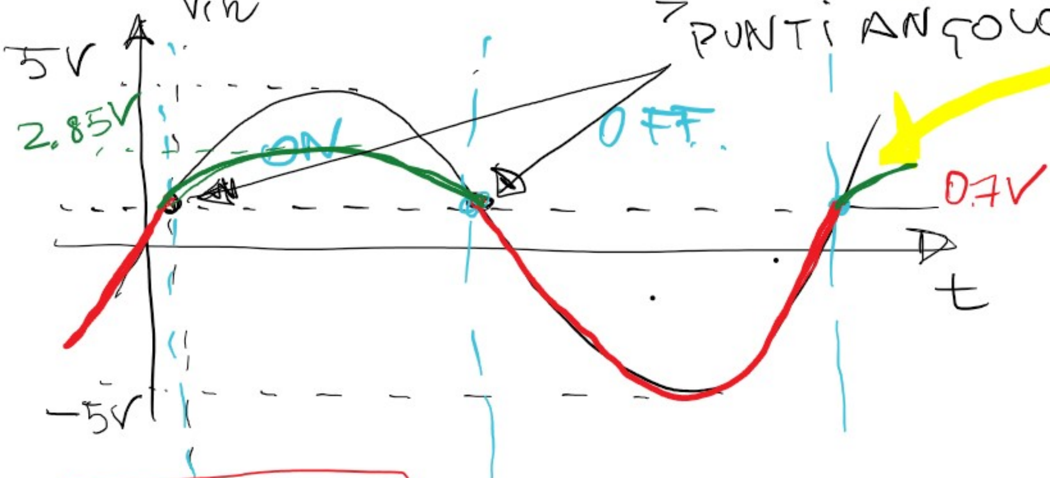
⇓ POL. DIRETTA



$R_1 = R_2 = 1k\Omega$

ⓐ Vout?

ⓑ $V_{BD} = -4V$



DIODO ON se $V_D \geq 0{,}7V$!

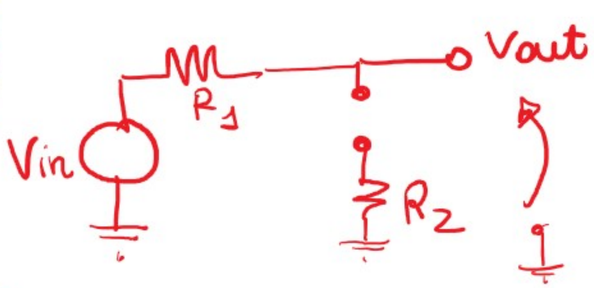
con diodo off $I_D = 0 \Rightarrow V_{out} = V_D$

$V_D \geq 0.7V \Leftrightarrow V_{out} \geq 0.7V$

se DIODO off $V_{out} = V_{in} \Rightarrow V_{in} \geq 0.7V$ per avere diodo ON

D on se $V_{in} \geq 0.7V$

Doff



$V_{out} = V_{in}$

Don

$V_{out} = \frac{V_{in}}{2} + 0.35V$

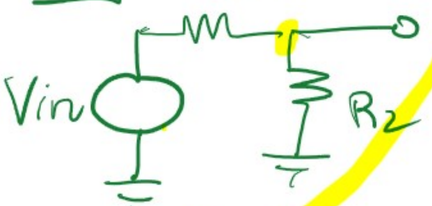
D on

$$V_{out} = \frac{V_{in}}{2} + 0.35V$$

$$V_{out,max} = \frac{5}{2} + 0.35V = 2.85V$$

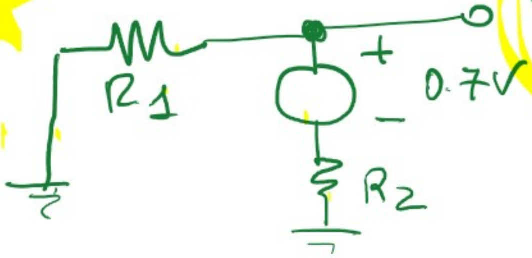
$$V_{out}(V_{in} = 0.7V) = \frac{0.7V}{2} + 0.35V = 0.7V$$

Vin



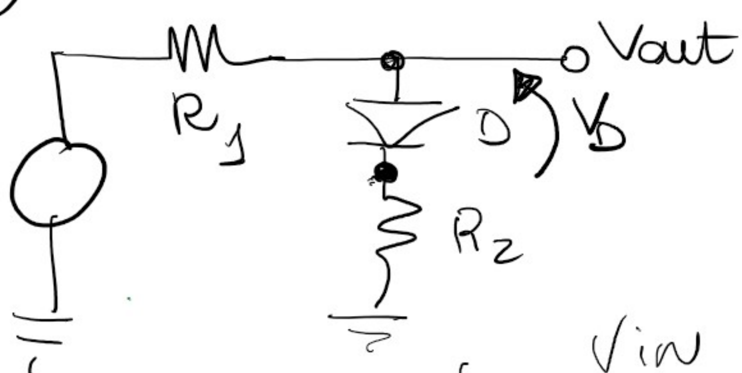
$$V_{out}\Big|_{V_{in}} = \frac{R_2}{R_1 + R_2} V_{in} = \frac{V_{in}}{2}$$

0.7V

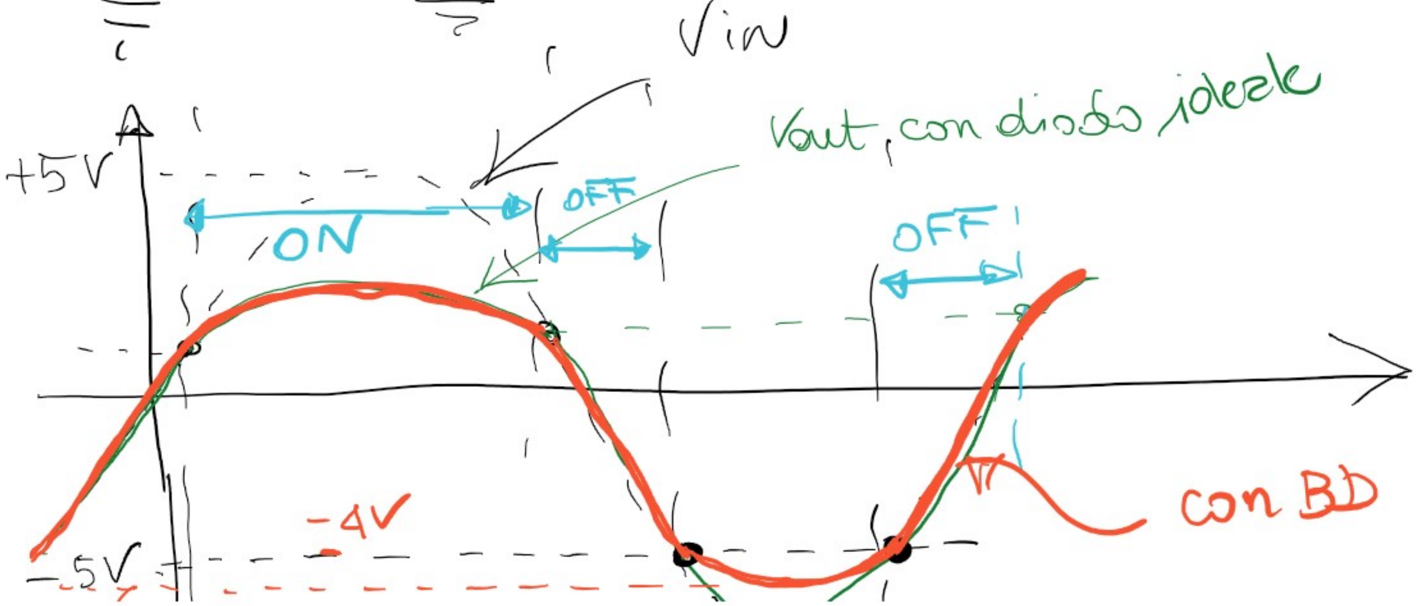


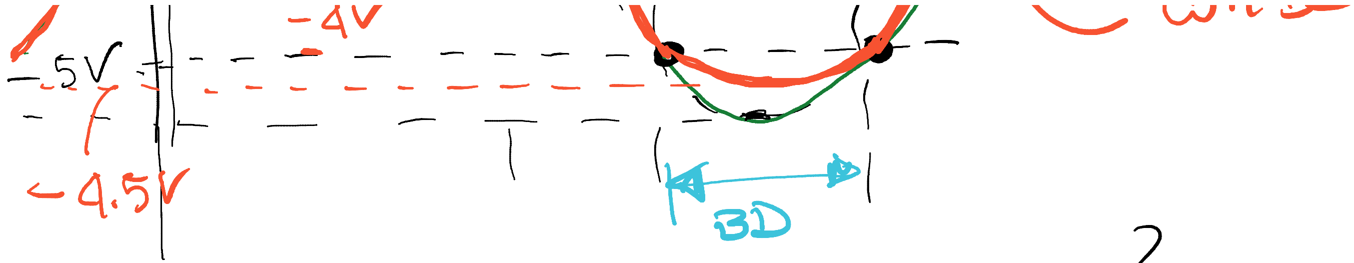
$$V_{out}\Big|_{0.7V} = 0.7V \frac{R_1}{R_1 + R_2} = 0.35V$$

5)



$$V_{BD} = -4V$$

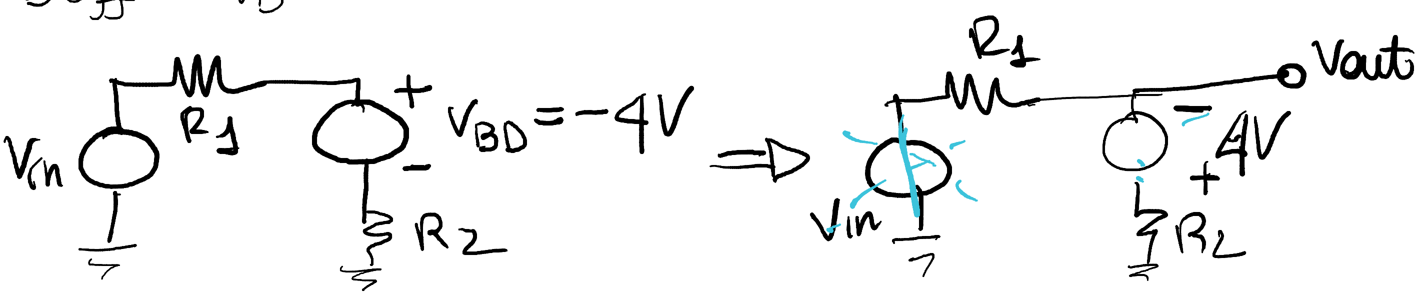




ΔV_{MAX} ai capi del diodo in inversa?

$V_{D\,MAX} = -5V$!! BD!

Doff $V_D = -4V \Rightarrow V_{in} = -4V$



$$V_{out} = \underbrace{\frac{R_2}{R_1+R_2}}_{V_{in}} V_{in} - \underbrace{4V\,\frac{R_1}{R_1+R_2}}_{-4V} =$$

$$= \frac{V_{in}}{2} - \frac{4V}{2} = \frac{V_{in}}{2} - 2V$$

$V_{in} = -5V \Rightarrow \quad V_{out} = -\frac{5}{2}V - 2V = -4.5V$

$V_{in} = -4V \Rightarrow \quad V_{out} = -\frac{4V}{2} - 2V = -4V$