SCHEMA e FORMULARIO

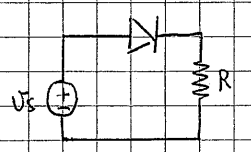
Legge di Schockley $i_d = I_S\left(e^{v_d/\eta V_T} - 1\right)$

RADDRIZZATORI = introducono una componente continua con media non nulla

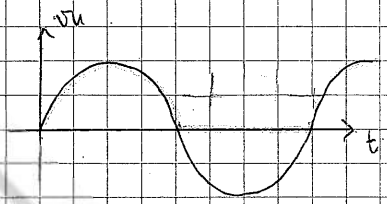
$V_{DC} = \frac{1}{T}\int_0^T v_u(t)\,dt$ $\quad V_{URMS} = \sqrt{\frac{1}{T}\int_0^T v_u(t)^2\,dt}$ $\quad R_F = \frac{V_{URMS}}{V_{DC}} = \sqrt{\frac{V_{URMS}^2 - V_{DC}^2}{V_{DC}}}$

$\eta_R = \frac{V_{DC}^2}{V_{URMS}^2} = \frac{1}{1+R_F^2}$ $\quad P_C = \frac{V_{DC}^2}{2}$ $\quad P_M = \frac{V_{URMS}^2}{R}$

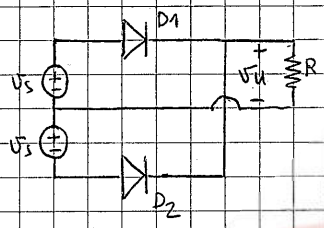
- A SEMPLICE SEMIONDA



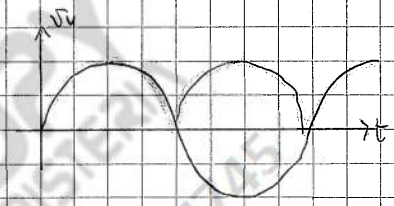
- $v_s > 0$ $\quad v_u = v_s$
- $v_s < 0$ $\quad v_u = 0$
- $v_s < v_\gamma$ $\quad v_u = 0$
- $v_s \geq v_\gamma$ $\quad v_u = v_s - v_\gamma$



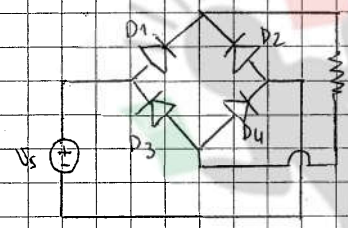
- A DOPPIA SEMIONDA CON PRESA CENTRALE



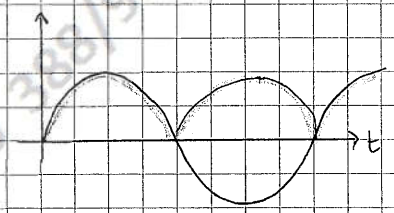
- $v_s > 0$ $\quad v_u = v_s$
- $v_s < 0$ $\quad v_u = -v_s$
- $v_s < v_\gamma$ $\quad v_u = 0$
- $v_s > v_\gamma$ $\quad v_u = v_s - v_\gamma$
- $v_s > -v_\gamma$ $\quad v_u = 0$
- $v_s < -v_\gamma$ $\quad v_u = -v_s - v_\gamma$



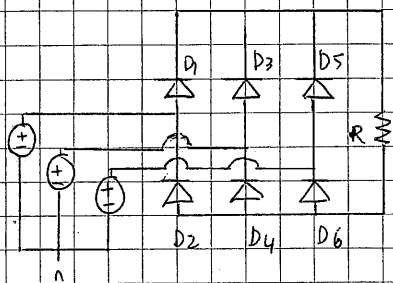
- A DOPPIA SEMIONDA CON PONTE DI GRAETZ



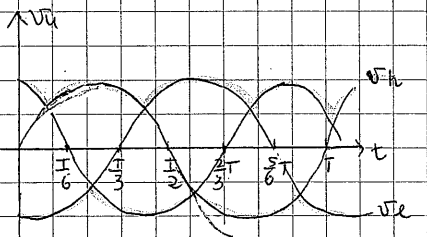
- $v_s > 0$ $\quad$ D1, D4 cond $\quad v_u = v_s$
- $v_s < 0$ $\quad$ D2, D3 cond $\quad v_u = -v_s$
- $v_s < 2v_\gamma$ $\quad v_u = 0$
- $v_s \geq 2v_\gamma$ $\quad v_u = v_s - 2v_\gamma$
- $v_s > -2v_\gamma$ $\quad v_u = 0$
- $v_s \leq -2v_\gamma$ $\quad v_u = -v_s - 2v_\gamma$



- ESAFASE



- sopra conduce chi riceve la tensione più alta
- sotto conduce chi riceve la tensione più bassa



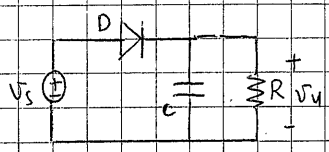
$v_u = v_h - v_l$

- corrente media: $\bar{i_D} = \frac{V_{DC}}{R} < i_{FAV}$
- corrente massima: $i_{max} = \frac{V_M}{R} < i_{FRM}$

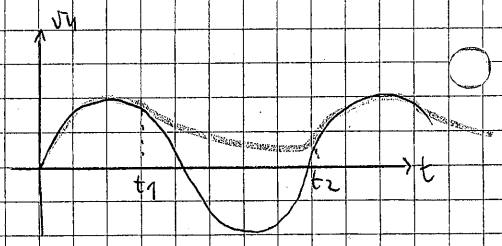
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FILTRI CAPACITIVI : smorzano le ondulazioni ed eliminano le componenti in alternata

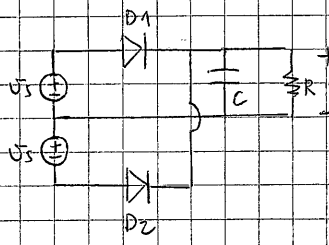
- **RADDRIZZATORE SEMPLICE + C**



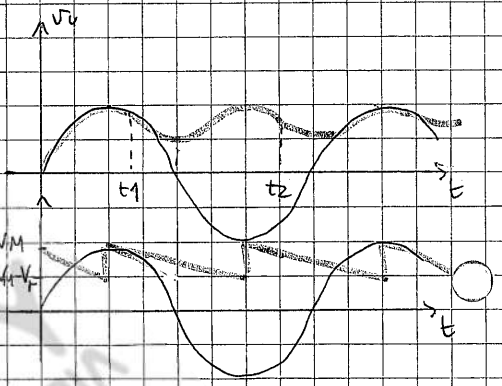
- $v_s > 0$, D cond fino a $i_D = 0$ in t_1; dopo il max $v_u = v_s$
- D int e $v_u = v_C = v_s(t_1)\, e^{-(t-t_1)/RC}$ scarica di C fino a $V_{AK} \geq 0$
- D cond quando $V_{AK} = V_{IN} - V_u \geq 0$



- **DOPPIA SEMIONDA + C**

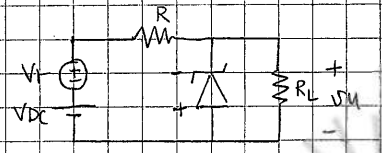


- $v_s > 0$ D_1 cond fino a $i_{D_1} = 0$ in t_1; dopo il max $v_u = v_s$
- D int e $v_u = v_C$, scarica C
- $v_s < 0$ D_2 cond, $v_u = -v_s$ fino a $i_{D_2} = 0$. Tutto int in t_2 e C h scarica



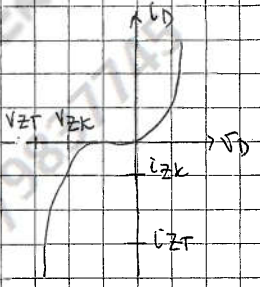
Approssimazione a onde di sega: $V_r = \frac{V_M}{2fRC} \simeq \frac{I_{DC}}{2fC}$

REGOLATORE DI TENSIONE



- i_{ZK} = corrente minima per entrare in BD
- i_{ZT} = " massima in BD

$$\Delta v_u = S_V \cdot \Delta v_{in} + S_T \Delta T + r_{out} \cdot \Delta i_{out}$$



$$dv_{out} = \frac{r_Z}{R + r_Z} dv_{in} + \frac{r_Z /\!/ R}{} di_{out}$$

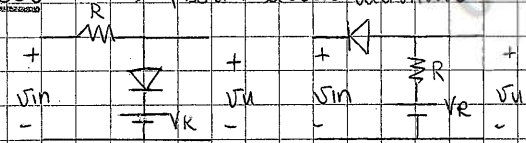


- $i_{Rmin} = \frac{V_{in\,min} - V_{BR}}{R} > i_{u\,max} + I_{ZK}$
- $P_{d\,max} = \frac{V_{in\,max} - V_{BR}}{R} V_{BR}$

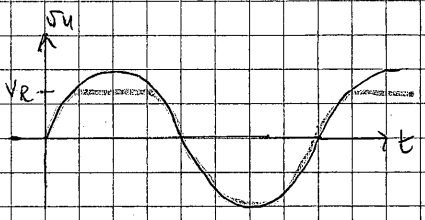
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TAGLIATORI

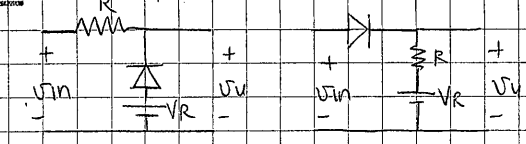
- **BASSO** : fissa il livello massimo



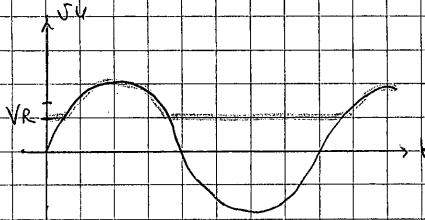
- $v_{in} < V_R$ D int $v_U = v_{in}$
- $v_{in} > v_R$ D cond $v_U = v_R$
- $v_{in} < v_R$ D cond $v_u = v_{in}$
- $v_{in} > v_R$ D int $v_U = v_R$



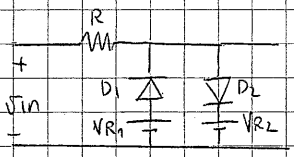
- **ALTO** : fissa il livello minimo



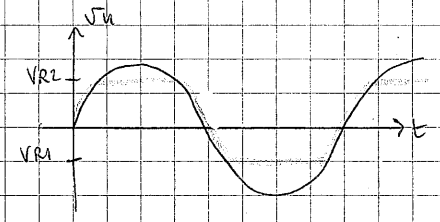
- $v_{in} < V_R$ D cond $v_U = V_R$
- $v_{in} > v_R$ D int $v_U = v_{in}$
- $v_{in} < v_R$ D int $v_U = v_R$
- $v_{in} > v_R$ D cond $v_U = v_{in}$

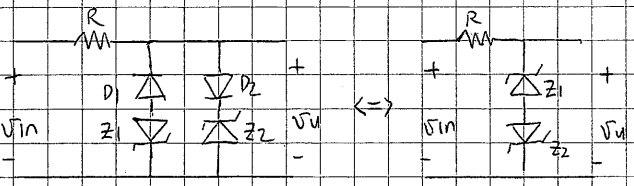


- **ALTO E BASSO**: alto a R_1 e basso a R_2



- $v_{in} < V_{R_1}$ D_1 cond, $v_u = v_{R_1}$
- $v_{in} > V_{R_2}$ D_2 cond $v_u = v_{R_2}$
- $V_{R_1} < v_{in} < V_{R_2}$ int $v_u = v_{in}$





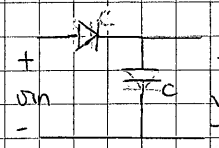
$V_{R1} = |V_{Z1}|$
$V_{R2} = |V_{Z2}|$

diodo in zona zener sostituito con un generatore Vz con polarità opposte al diodo

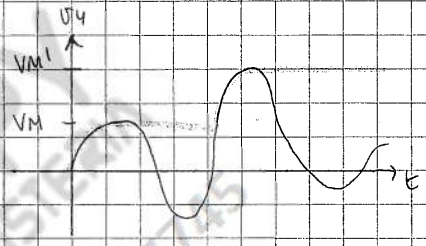
- $v_{in} < -|V_Z|$ Z_1 cond, Z_2 BD $v_u = -|V_Z|$
- $v_{in} > |V_Z|$ Z_1 BD, Z_2 cond $v_u = |V_Z|$
- $v_{in} \in (-V_Z, V_Z)$ int $v_u = v_{in}$

RILEVATORI DI PICCO

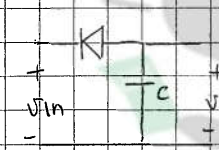
- **POSITIVO**



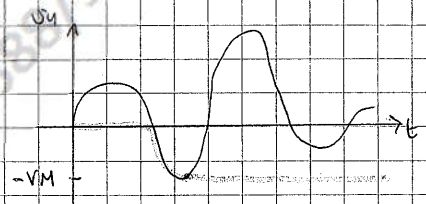
- $v_{in} > 0$ D cond, $v_u = v_{in}$
- D INT quando $i_D = 0$, $V_C = V_M$ $v_u = V_M - V_M'$
- D torna a cond $v_u = v_{in}$ e C si scarica
- D int quando $i_D > 0$ $V_C = V_M'$ $V_u = V_{M'}$



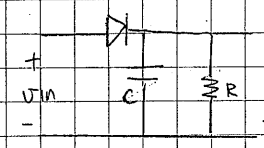
- **NEGATIVO**



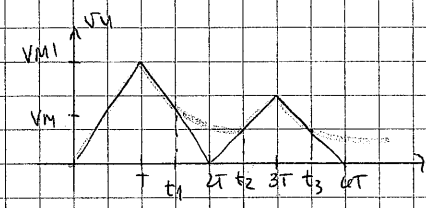
- $v_{in} > 0$ D INT $v_u = 0$
- $v_{in} < 0$ D cond $v_u = v_{in}$
- D int quando $i_D = 0$, $V_C = -V_M$, $V_u = -V_M$



- **RILEVATORE DI INVILUPPO** (raddrizzatore + C)



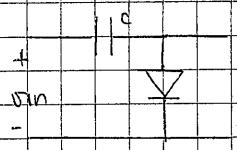
- $v_{in} > 0$ D cond $v_u = v_{in}$
- D int quando $i_D = 0$ in t_1 $v_u = v_C = V_{in}(t_1)\, e^{-(t-t_1)/RC}$ fino a che $V_{AK} = V_{in} - V_u \geq 0$
- D cond in t_2 e $v_u = v_{in}$ fino a che $i_D = 0$ in t_3



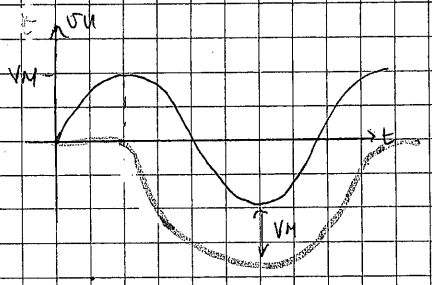
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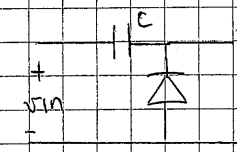
- **IN ALTO A ZERO** impone limite massimo = 0



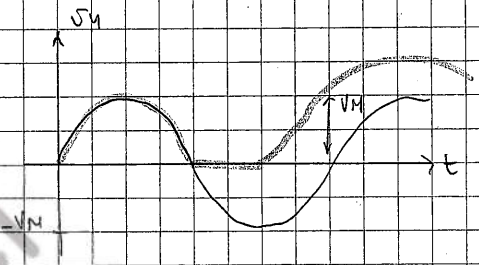
- $v_{in} > 0$ $v_u = 0$ D cond
- D int quando $i_D = 0$, $v_C = V_M$, $v_u = v_{in} - V_M$ fino a che $V_{AK} = v_{in} - v_C < 0$ ovvero sempre



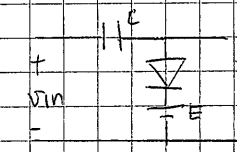
- **IN BASSO A ZERO**



- $v_{in} > 0$ D int $v_u = v_{in}$
- $v_{in} < 0$ D cond $v_u = 0$ fino a $i_D = 0$, $v_C = -V_M$
- D int e $v_u = v_{in} + v_C = v_{in} + V_M$ fino a che $V_{AK} = -v_{in} - V_M < 0$ ovvero sempre



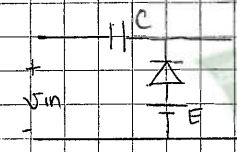
- **ALTO A UN VALORE E**



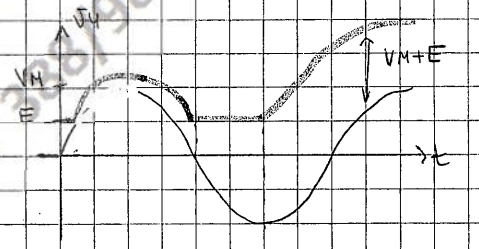
- $v_{in} < E$ D int, $v_u = v_{in}$
- $v_{in} \geq E$ D cond, $v_u = E$ fino a $i_D = 0$, $v_C = V_M - E$
- D int $v_u = v_{in} - v_C = v_{in} - V_M + E$ fino a che $V_{AK} = v_{in} - V_M < 0$ ovvero sempre



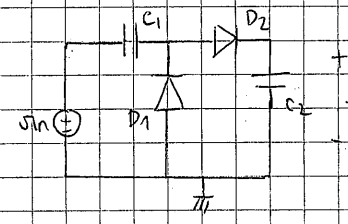
- **BASSO A UN VALORE E**

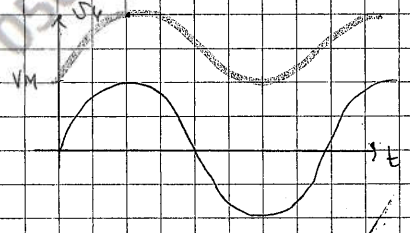


- $v_{in} \leq E$ D cond, $v_u = E$
- $v_{in} > E$ D int $v_u = v_{in} - v_C = v_{in} - E$
- $v_{in} < 0$ D cond $v_u = E$ fino a $i_D \neq 0$
- D int e $v_u = v_{in} - v_C = v_{in} + V_M + E$



- **RIEEVATORE PICCO-PICCO** = fissatore basso-zero + rilevatore picco positivo





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Parametri

F

$$\begin{cases} i_{in} = f_i \cdot v_{in} + f_r \cdot i_{out} \\ v_{out} = f_f \cdot v_{in} + f_o \cdot i_{out} \end{cases}$$

Amp. di tensione ideale con $f_i \simeq \infty$, $f_o \simeq 0$

H

$$\begin{cases} v_{in} = h_i \cdot i_{in} + h_r \cdot v_{out} \\ i_{out} = h_f \cdot i_{in} + h_o \cdot v_{out} \end{cases}$$

Amp. di corrente ideale con $h_i \simeq 0$, $h_o \simeq \infty$

G

$$\begin{cases} i_{in} = g_i \cdot v_{in} + g_r \cdot v_{out} \\ i_{out} = g_f \cdot v_{in} + g_o \cdot v_{out} \end{cases}$$

Amp transconduttivo ideale con $g_i \simeq 0$ $g_o \simeq 0$

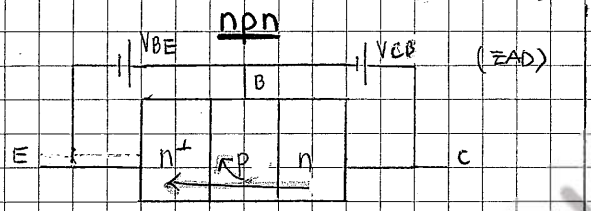
R

$$\begin{cases} v_{in} = r_i \cdot i_{in} + r_r \cdot i_{out} \\ v_{out} = r_f \cdot i_{in} + r_o \cdot i_{out} \end{cases}$$

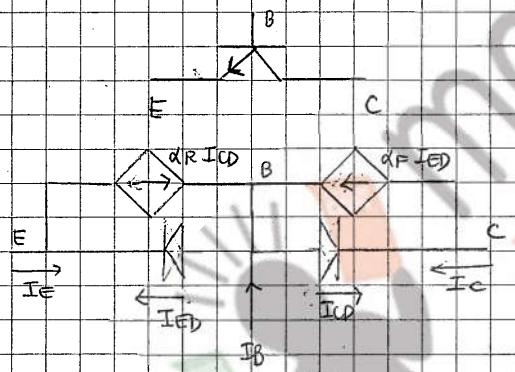
Amp resistivo ideale con $r_o \simeq 0$, $r_i \simeq 0$

BJT

npn



Elettroni diffondono da n+ a p e sono trascinati dal campo elettrico



$$I_E = -I_{ED} + \alpha_R I_{CD} = -I_{ES}\left(e^{V_{EB}/V_T} - 1\right) + \alpha_R I_{CS}\left(e^{V_{CB}/V_T} - 1\right)$$

$$I_C = -I_{CD} + \alpha_F I_{ED} = -I_{CS}\left(e^{V_{CB}/V_T} - 1\right) + \alpha_F I_{ES}\left(e^{V_{EB}/V_T} - 1\right)$$

ZAD

$$I_E \simeq -I_{ED}$$
$$I_C \simeq \alpha_F I_{ED}$$
$$I_B = -I_E - I_C \simeq I_{ED}(1 - \alpha_F)$$

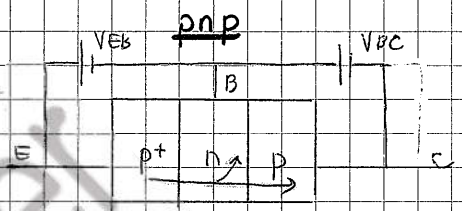
$$\frac{I_C}{I_B} = \frac{\alpha_F}{1-\alpha_F} = \beta_F = h_{FE}$$

ZAI

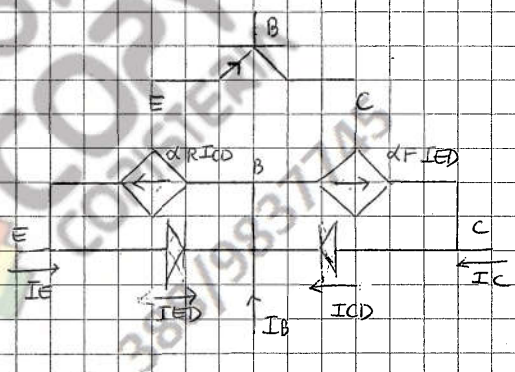
$$I_E \simeq \alpha_R I_{CD}$$
$$I_C \simeq -I_{CD}$$
$$I_B = -I_E - I_C = I_{CD}(1 - \alpha_R)$$

$$\frac{I_E}{I_B} \simeq \frac{\alpha_R}{1-\alpha_R} = \beta_R = h_{RE}$$

pnp



Lacune diffondono da p+ a n e sono trascinate dal campo elettrico



$$I_E = -\alpha_R I_{CD} + I_{ED} = -\alpha_R I_{CS}\left(e^{V_{BC}/V_T} - 1\right) + I_{ES}\left(e^{V_{EB}/V_T} - 1\right)$$

$$I_C = -\alpha_F I_{ED} + I_{CD} = \alpha_F I_{ES}\left(e^{V_{EB}/V_T} - 1\right) + I_{CS}\left(e^{V_{BC}/V_T} - 1\right)$$

ZAD

$$I_E \simeq I_{ED}$$
$$I_C \simeq +\alpha_F I_{ED}$$
$$I_B = +I_E - I_C \simeq I_{ED}(\alpha_F - 1)$$

$$\frac{I_C}{I_B} = \frac{-\alpha_F}{\alpha_F - 1} = \frac{\alpha_F}{1-\alpha_F} = \beta_F = h_{FE}$$

ZAI

$$I_E \simeq -\alpha_R I_{CD}$$
$$I_C \simeq I_{CD}$$
$$I_B = -I_E - I_C \simeq (\alpha_R - 1) I_{CD}$$

$$\frac{I_E}{I_B} = \frac{-\alpha_R}{\alpha_R - 1} = \frac{\alpha_R}{1-\alpha_R} = \beta_R = h_{RE}$$

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