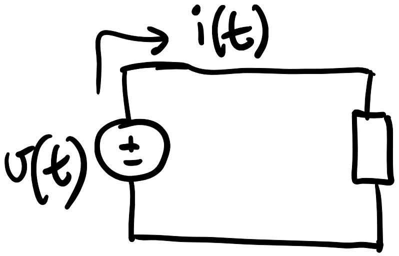
Raddrizzatori a frequenza di linea



$v(t), i(t)$ PERIODICHE, NON SINUSOIDALI

$$v(t) = V_0 + \sum_{n=1}^{\infty} V_n \cos(n\omega t - \phi_n)$$

$$i(t) = I_0 + \sum_{n=1}^{\infty} I_n \cos(n\omega t - \theta_n)$$

$$p(t) = v(t)\, i(t)$$

$$P_{av} = \frac{1}{T}\int_0^T v(t)\, i(t)\, dt = \underbrace{V_0 I_0 + \sum_{n=1}^{\infty} \frac{V_n I_n}{2} \cos(\phi_n - \theta_n)}$$

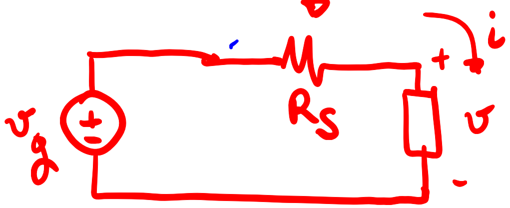
Power Factor $\quad PF \triangleq \dfrac{P_{av}}{V_{RMS}\, I_{RMS}}$

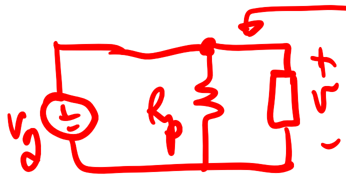
$$V_{RMS} = \left[\frac{1}{T}\int_0^T v^2(t)\, dt\right]^{1/2} = \left[V_0^2 + \sum_{n=1}^{\infty} \frac{V_n^2}{2}\right]^{1/2}$$

$$I_{RMS} = \left[\frac{1}{T}\int_0^T i^2(t)\, dt\right]^{1/2} = \left[I_0^2 + \sum_{n=1}^{\infty} \frac{I_n^2}{2}\right]^{1/2}$$

$$0 \leq PF \leq 1$$

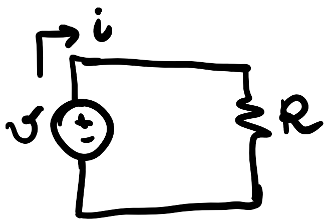
PERDITA NELLA RESISTENZA SERIE $\underline{R_S I_{RMS}^2}$





PERDITA NELLA NELLA RESISTENZA PARALLELO $R_P V_{RMS}^2$

TENSIONE NON SINUSOIDALE CON CARICO RESISTIVO



$$v(t) = V_0 + \sum_{n=1}^{\infty} V_n \cos(n\omega t - \phi_n)$$

$$i(t) = \frac{V_0}{R} + \sum_{n=1}^{\infty} \frac{V_n}{R} \cos(n\omega t - \phi_n)$$

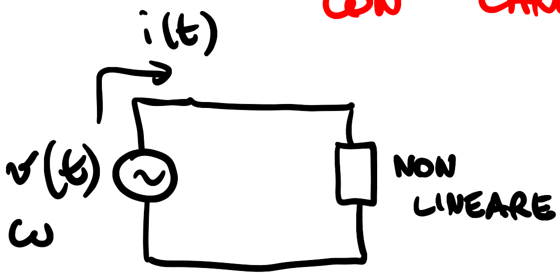
$$\left[\begin{array}{l} \theta_n = \phi_n \\ I_n = \frac{V_n}{R} \end{array} \right]$$

$$\Rightarrow \quad P_{av} = \frac{V_0^2}{R} + \sum_{n=1}^{\infty} \frac{V_n^2}{2R} = \frac{V_{RMS}^2}{R}$$

$$I_{RMS} = \frac{V_{RMS}}{R}$$

$$PF = \frac{P_{av}}{V_{RMS} I_{RMS}} = 1$$

GENERATORE DI TENSIONE SINUSOIDALE CON CARICO NON LINEARE



$$v(t) = V_1 \cos(\omega t - \phi_1)$$

$$i(t) = I_0 + \sum_{n=1}^{\infty} I_n \cos(n\omega t - \theta_n)$$

$$P_{av} = \frac{V_1 I_1}{2} \cos(\phi_1 - \theta_1)$$

$$V_{RMS} = \frac{V_1}{\sqrt{2}}$$

$$I_{RMS} = \left[I_0^2 + \sum_{n=1}^{\infty} \frac{I_n^2}{2} \right]^{1/2}$$

$$\Rightarrow PF = \frac{\frac{\cancel{V_1} I_1}{\sqrt{2}\,\cancel{2}} \cos(\phi_1 - \theta_1)}{\frac{\cancel{V_1}}{\cancel{\sqrt{2}}} \cdot \sqrt{\left(I_0^2 + \sum_{n=1}^{\infty} \frac{I_n^2}{2} \right)}}$$

$$PF = \underbrace{\frac{1}{\sqrt{\dfrac{I_0^2 + \sum_{n=1}^{\infty} \frac{I_n^2}{2}}{I_n^2/2}}}}_{\text{FATTORE DI DISTORSIONE}} \cdot \underbrace{\cos(\phi_1 - \theta_1)}_{\text{FATTORE DI SFASAMENTO}}$$

THD Total Harmonic Distorsion

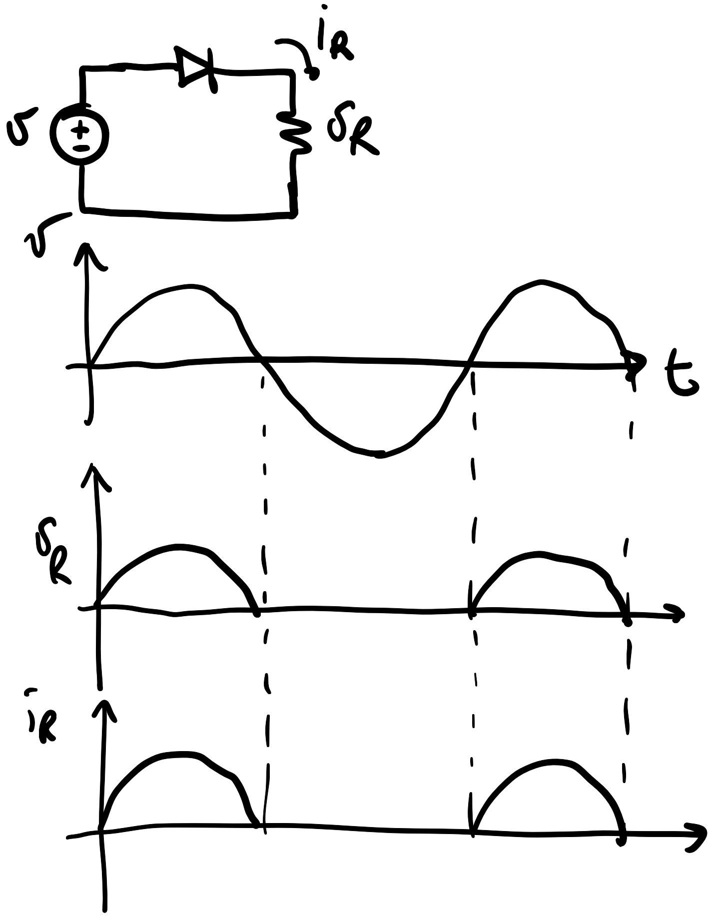
$$THD \triangleq \frac{\text{Valore RMS del segnale} - \text{la prima armonica}}{\text{RMS della prima armonica}} = \frac{\left[I_0^2 + \sum_{n=2}^{\infty} \frac{I_n^2}{2} \right]^{1/2}}{\frac{I_1}{\sqrt{2}}}$$

$$\Rightarrow \boxed{PF = \frac{1}{\sqrt{1 + THD^2}} \cos(\phi_1 - \theta_1)}$$

SINGOLA SEMIONDA

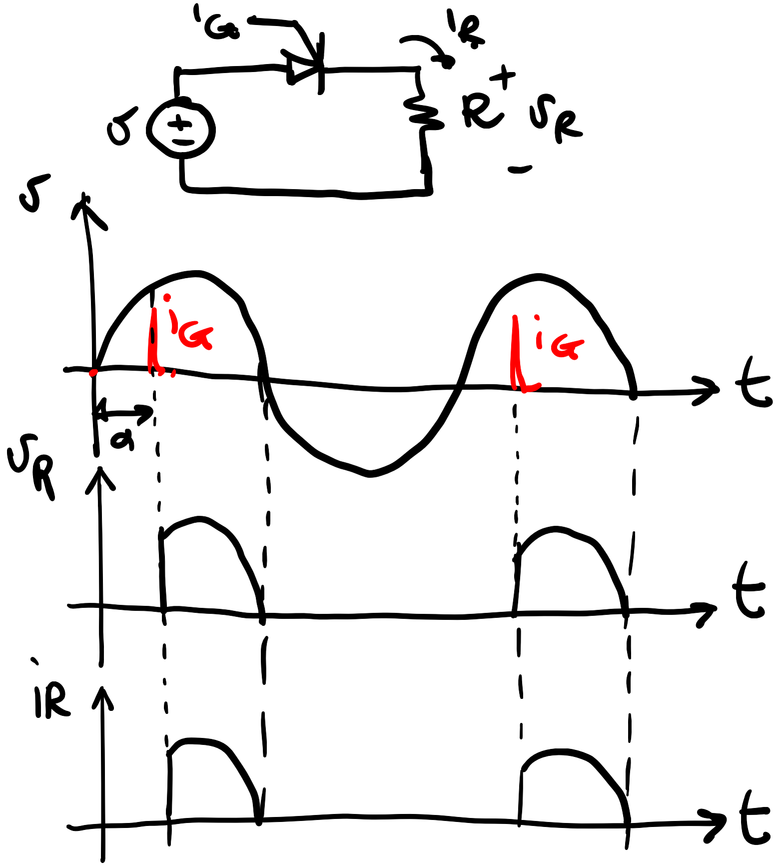
Raddrizzatore a diodo

con carico RESISTIVO



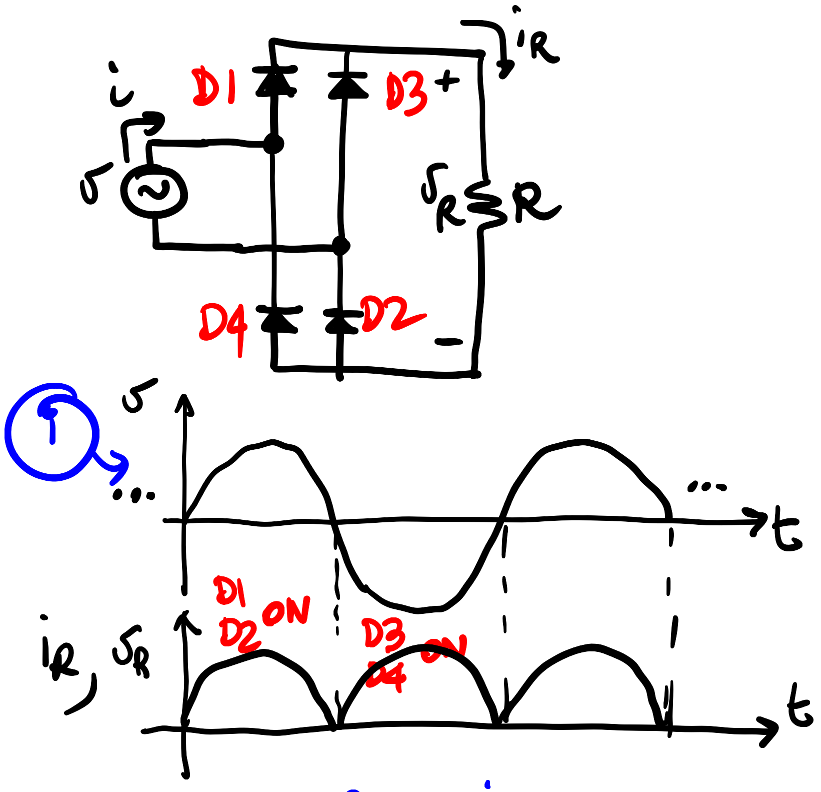
Raddrizzatore con SCR (TIRISTORE)

con carico RESISTIVO



DOPPIA SEMIONDA (FULL BRIDGE)

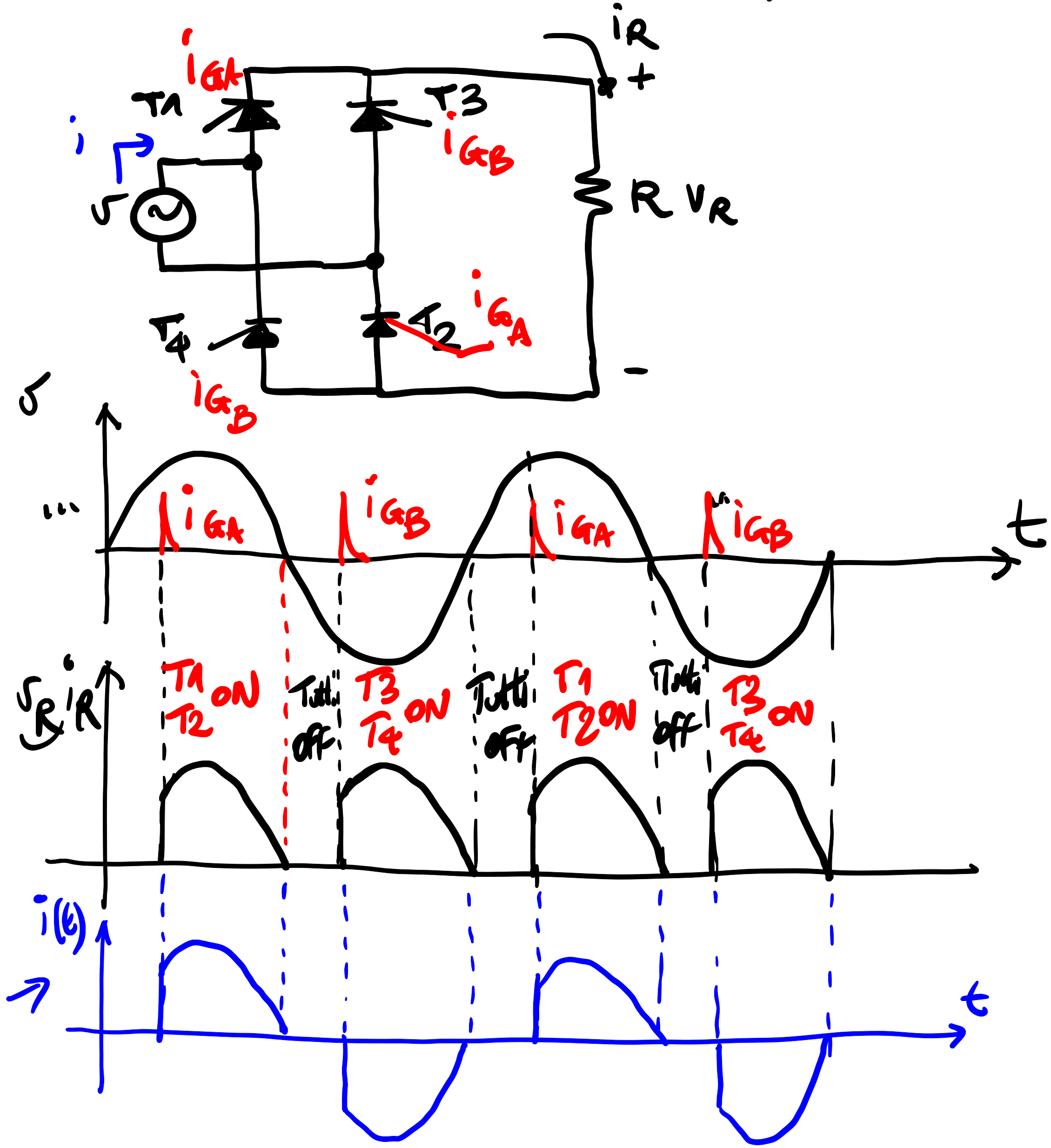
DIODI (carico R...)



$PF = 1$

CORRENTE i SINUSOIDALE

SCR (carico Resistivo)



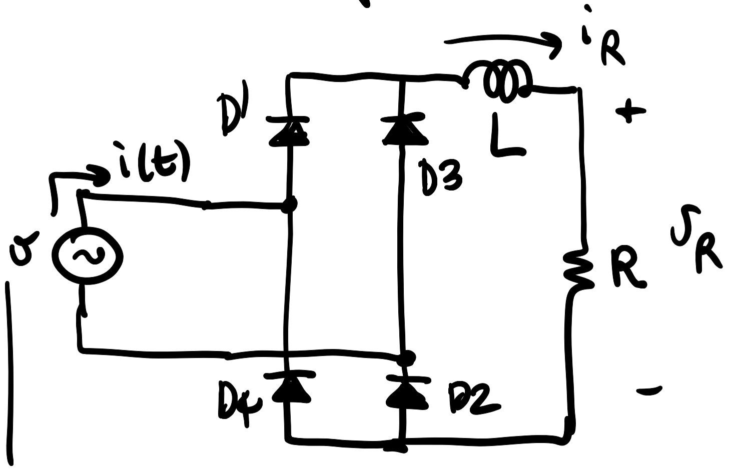
$PF < 1$

perché $THD > 0$

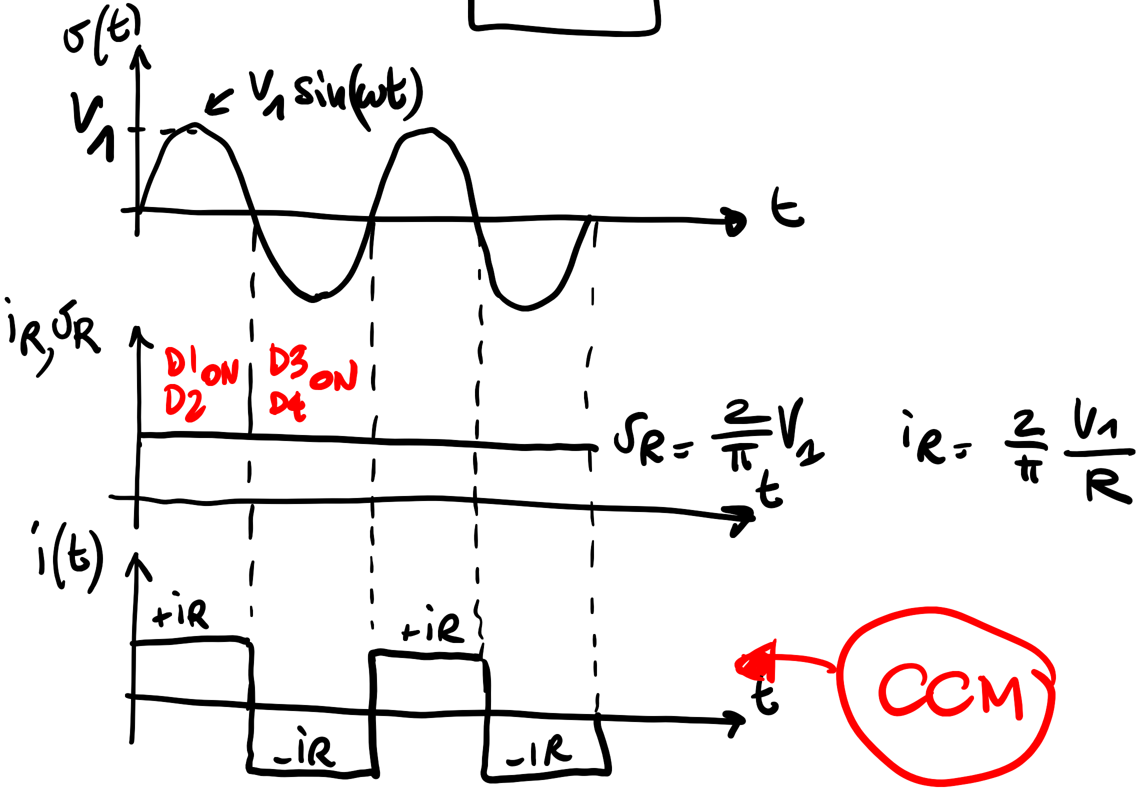
$\cos\phi \cong 1$

Carico con filtro INDUTTIVO (induttanza serie)

$\boxed{\text{LIMITE } L \to \infty}$



$v = V_1 \sin(\omega t)$



$$i_R = \frac{2}{\pi}\frac{V_1}{R}$$

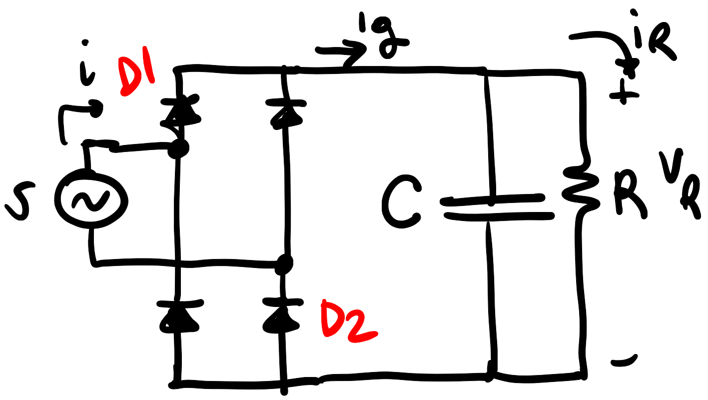
$$PF = \underbrace{\frac{1}{\sqrt{1+THD^2}}}_{0.9} \cdot \cos\phi = 0.9$$

$(\phi_1 - \theta_1)$

$\cos\phi$: Fattore di sfasamento → 1

Carico con filtro capacitivo [capacità parallela]

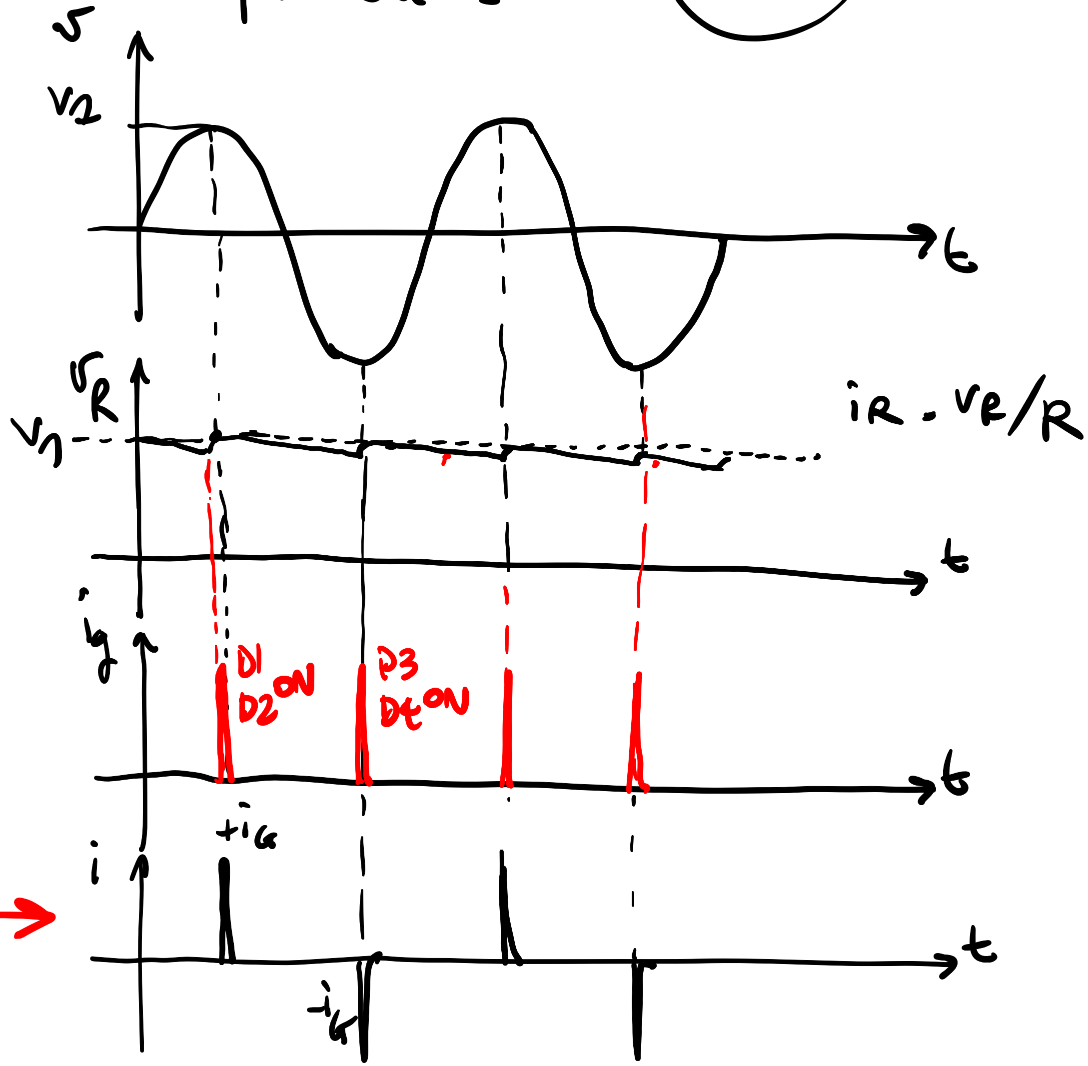
$C \to \infty$



$v = V_1 \sin(\omega t)$

$$PF = \underbrace{\frac{1}{\sqrt{1+THD^2}}}_{\infty} \underbrace{\cos\phi}_{1} \sim 0$$

DCM



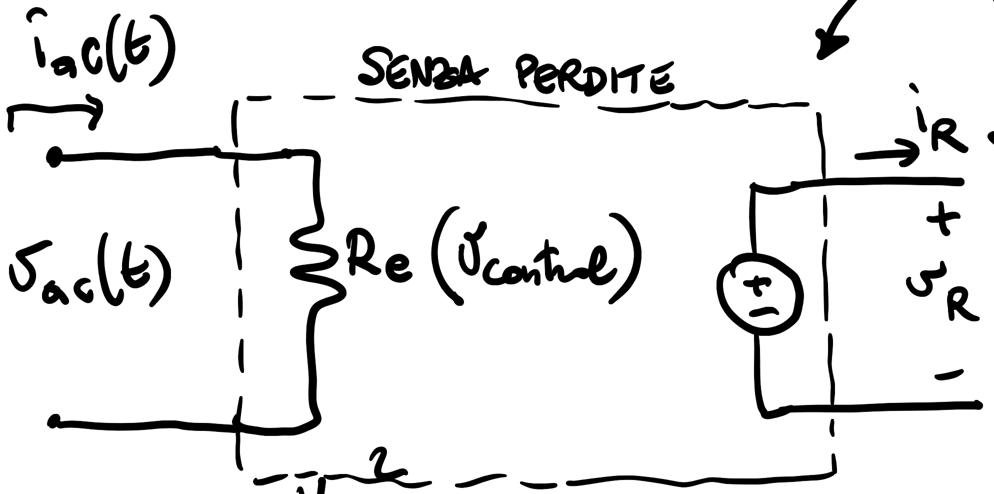
Raddrizzatori moderni

↳ basati sugli stessi principi dei convertitori DC-DC switching

↳ SI CONTROLLA LA FORMA D'ONDA DELLA CORRENTE DI INGRESSO IN MODO DA RENDERLA **SINUSOIDALE** e in fase con la TENSIONE DI INGRESSO

per avere $PF \to 1$

[LOSS-FREE RESISTOR]

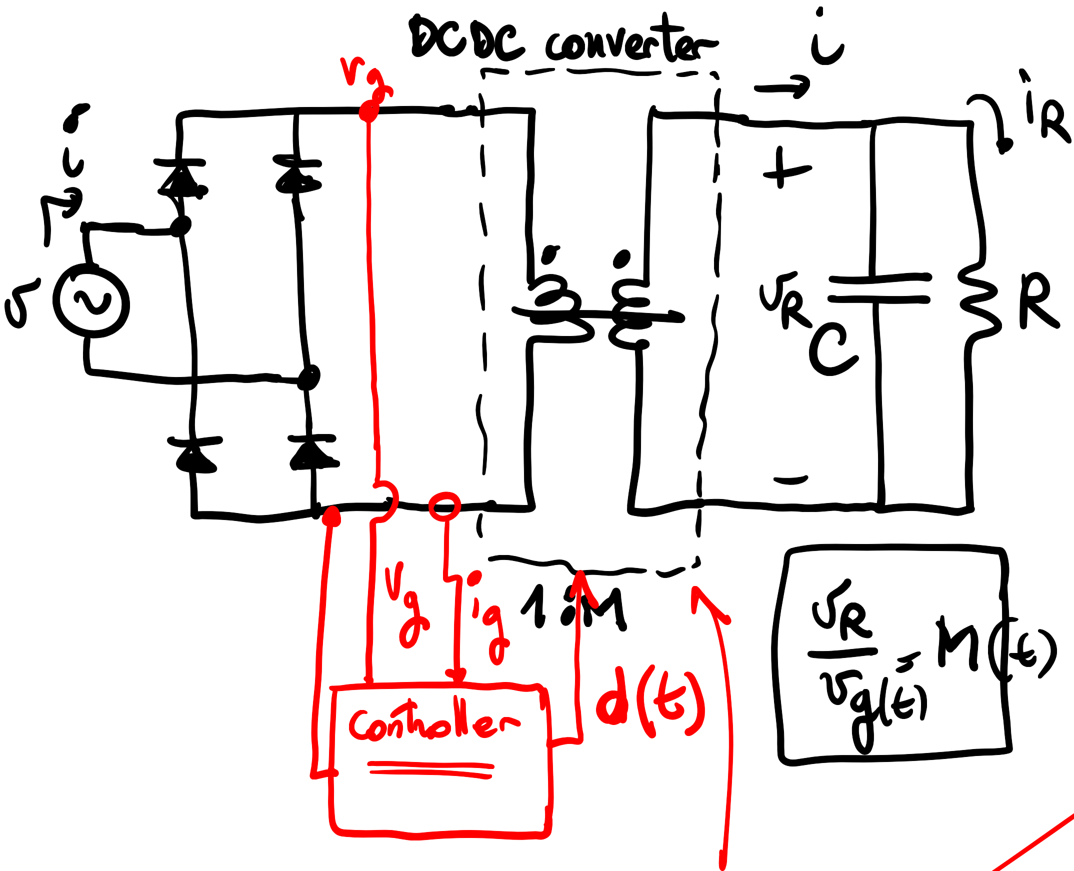


$$\frac{V_{ac,RMS}^2}{R_e} = V_R I_R$$

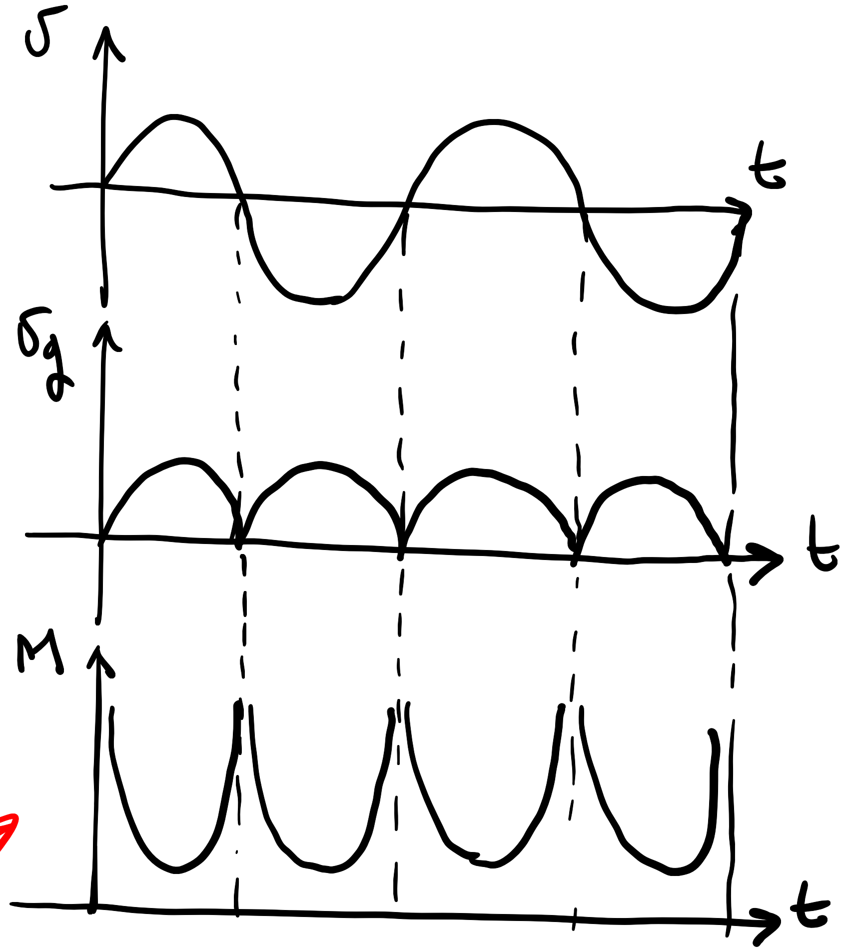
$$i_{ac}(t) = \frac{v_{ac}(t)}{R_e}$$

$$PF = \underbrace{\frac{1}{\sqrt{1+THD^2}}}_{\uparrow\ 1} \underbrace{\cos(\phi_1 - \theta_1)}_{\uparrow\ 1} = 1$$

Raddrizzatore ideale



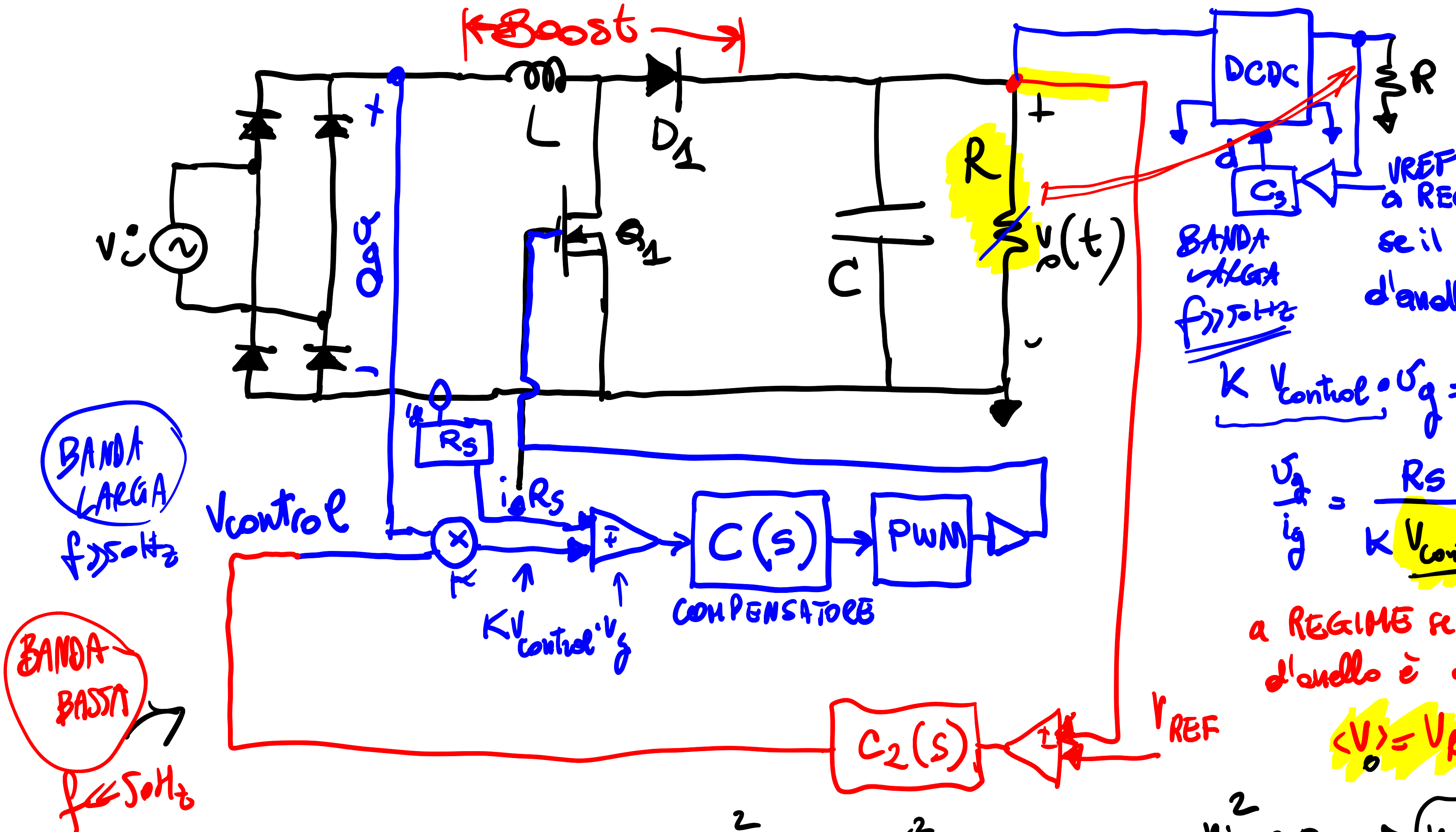
$$\boxed{\frac{v_R}{v_g(t)} = M(t)}$$



Boost

Perché M deve poter essere grande

$$\boxed{M = \frac{1}{1-D}}$$



VREF a REGIME se il guadagno d'anello è alto:

$$\underbrace{K\, V_{control} \cdot v_g} = \underbrace{R_s\, i_g}$$

$$\frac{v_g}{i_g} = \frac{R_s}{K\, V_{control}} = R_e$$

a REGIME se il guadagno d'anello è alto

$$\langle V_o \rangle = V_{REF}$$

IN ASSENZA DI PERDITE:

$$\underbrace{\frac{v_{i\,RMS}^2}{R_e}}_{PIN} = \underbrace{\frac{V_o^2}{R}}_{POUT} \rightarrow \quad R_e = \frac{v_{i\,RMS}^2}{V_o^2} R \Rightarrow \boxed{V_{control} = \frac{R_s}{K R_e}}$$