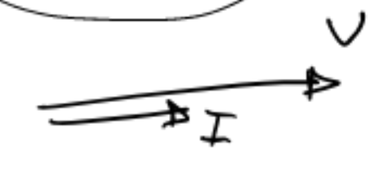
RIEPILOGO IMPEDENZE

$$V = Z_R \cdot I$$

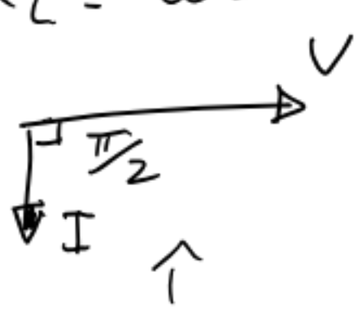
$$Z_R = R$$

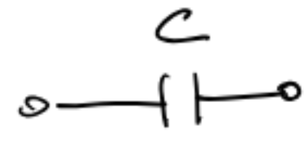


$$V = Z_L \cdot I$$

$$Z_L = j X_L$$

$$X_L = \omega L$$

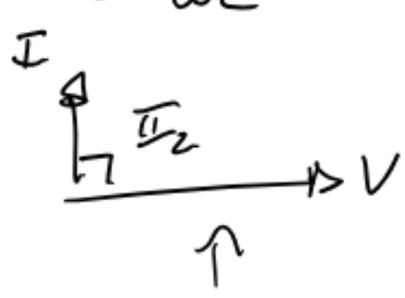




$$V = Z_C I$$

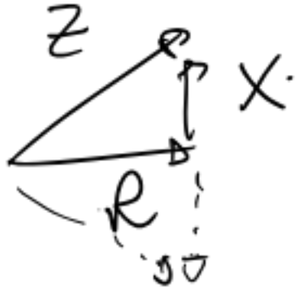
$$Z_C = -j X_C$$

$$X_C = \frac{1}{\omega C}$$

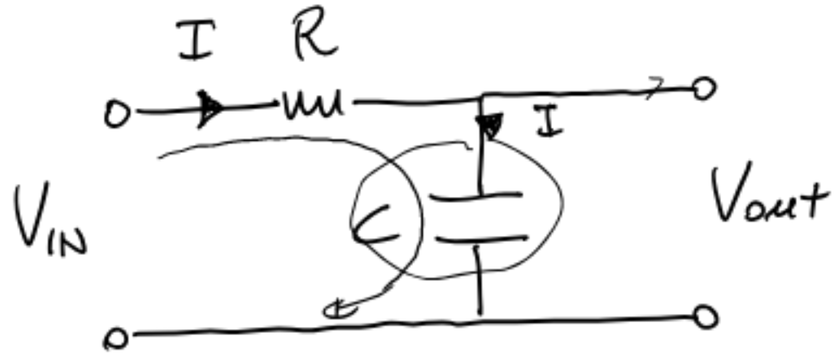


R serie / parallelo

$$Z = R + jX$$



FILTRO RC — REGIME SINUSOIDALE



Funzione di trasferimento

$$T = \left| \frac{V_{out}}{V_{in}} \right|$$

$$\bar{T} = \frac{V_{out}}{V_{in}}$$

$$V_{out} = Z_C \cdot I \qquad I = \frac{V_{in}}{Z} \qquad Z = R - jX_C$$

$$X_C = \frac{1}{\omega C}$$

$$= \frac{Z_C \cdot I}{V_{in}} = \frac{Z_C \, V_{in}}{Z \, V_{in}} = \frac{-jX}{R - jX_C} \cdot (R + jX_C) = \frac{X_C^2 - jRX_C}{R^2 + X_C^2}$$

$$|\bar{T}| = T = \frac{1}{R^2 + X_C^2} \sqrt{X_C^4 + R^2 X_C^2} = \frac{X_C}{R^2 + X_C^2} \sqrt{R^2 + X_C^2} =$$

$$= \frac{X_C}{\sqrt{R^2 + X_C^2}} = \frac{1}{\omega C \sqrt{R^2 + \frac{1}{\omega^2 C^2}}} = \frac{1}{\sqrt{1 + (\omega RC)^2}}$$

$$T = \frac{1}{\sqrt{1 + (\omega RC)^2}} =$$

$\omega \to 0 \rightarrow 1$

$\omega \to +\infty \rightarrow 0$

$(\omega RC)^2 \to +\infty$

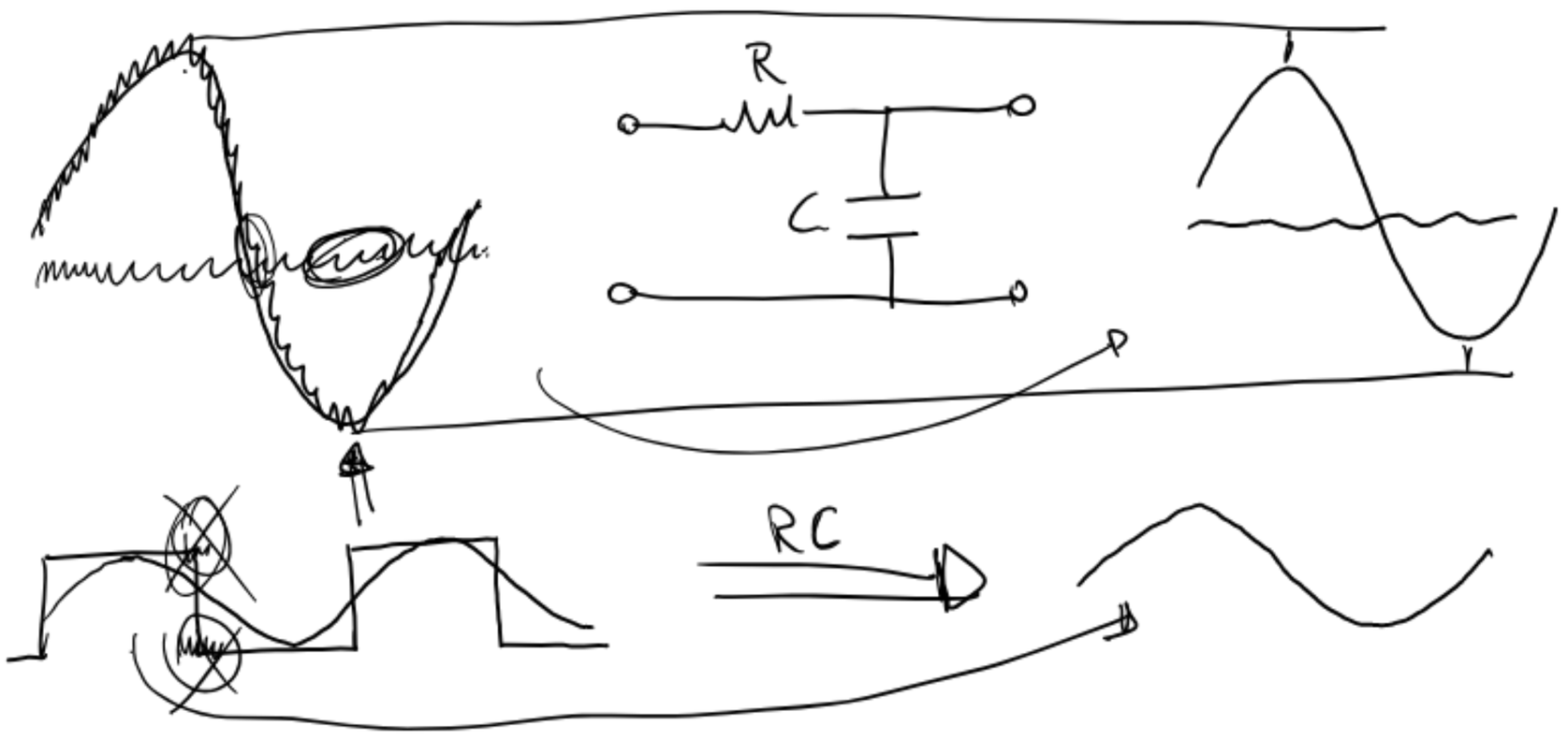
$|V_{out}| \simeq |V_{in}|$

$V_{out} \simeq 0$

$\left|\frac{V_{out}}{V_{in}}\right|$

$\omega = 2\pi f$

FILTRO PASSA BASSO

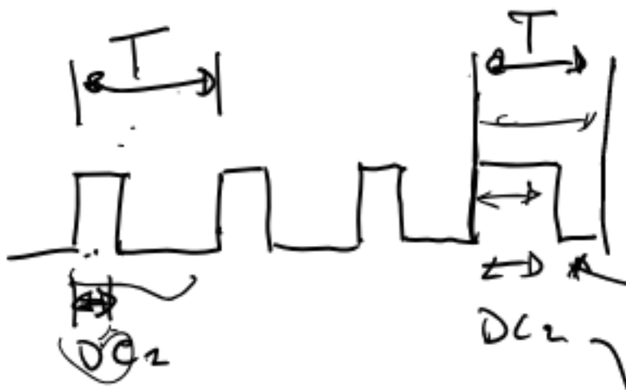


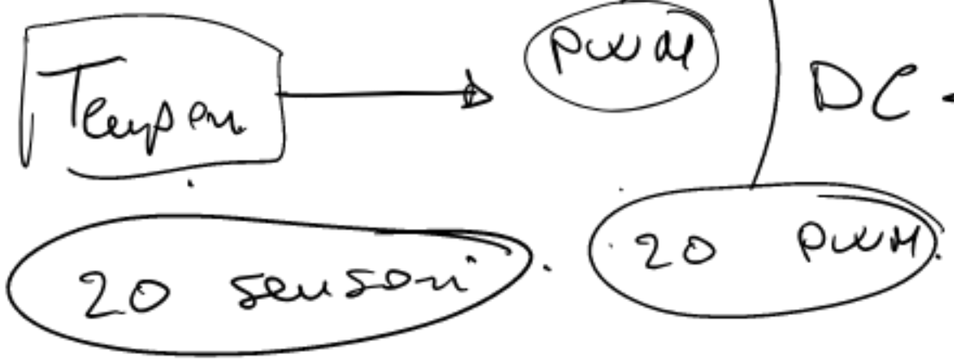
RC

Es. appl. filtro RC

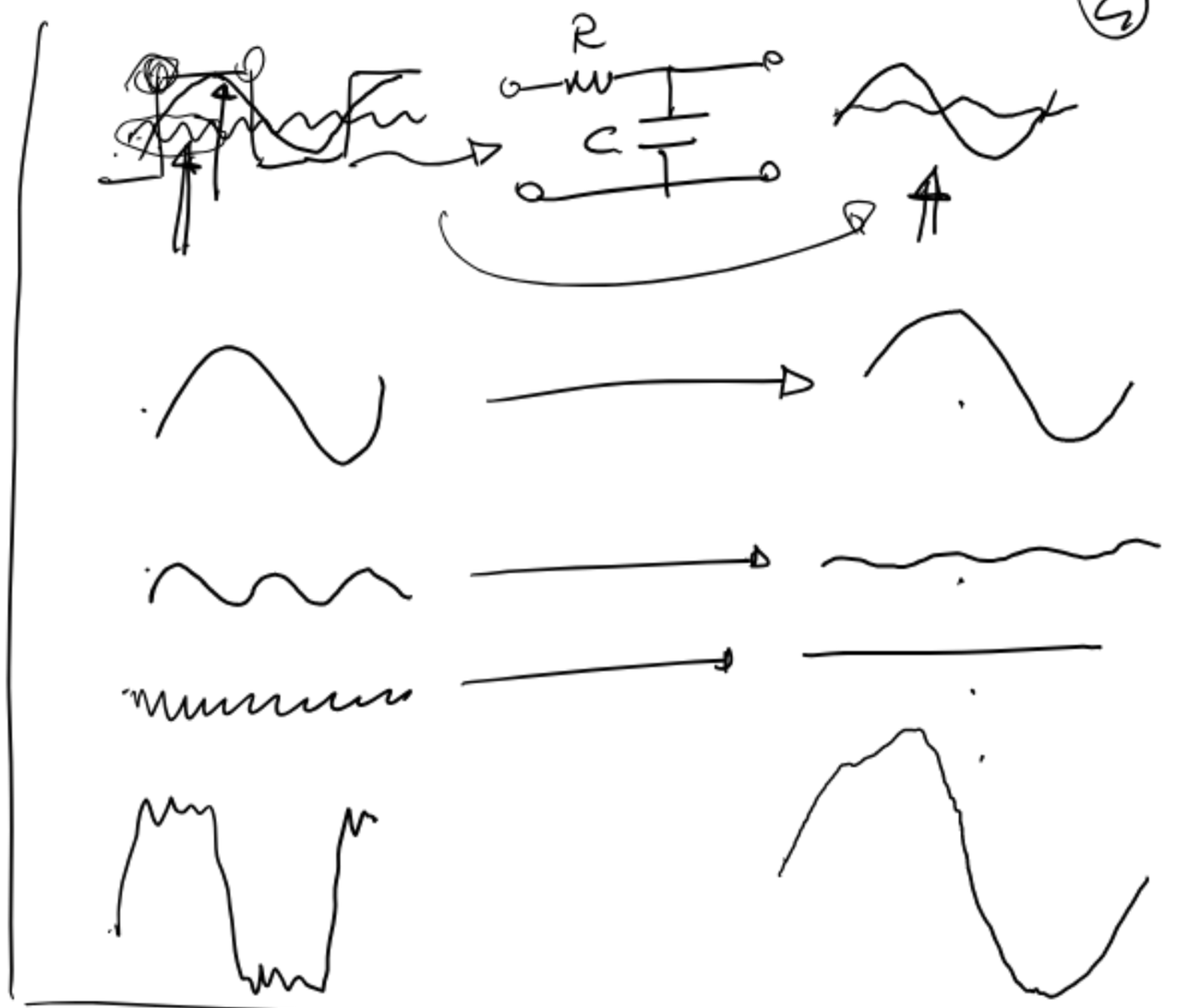
"trasformare" segnale PWM in segnale analogico continuo.

PWM ⟶ Analogico.



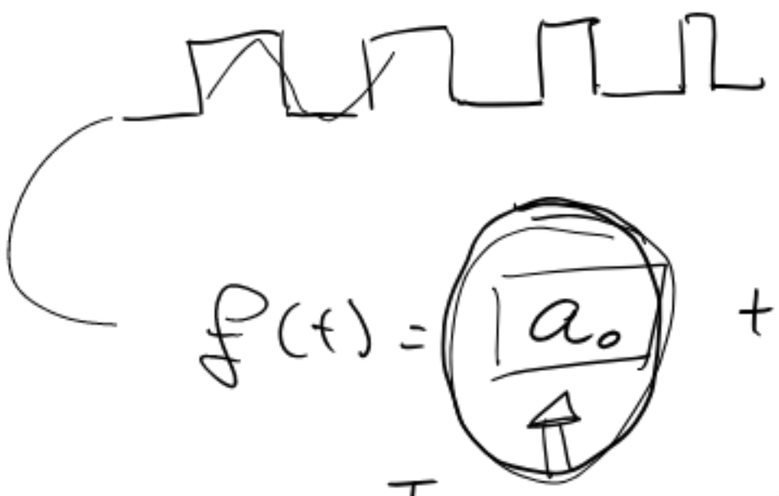


DC ∝ Temp.



PWM ⟶ RC ⟶ V_{SENSE} ∝ DC ⟹

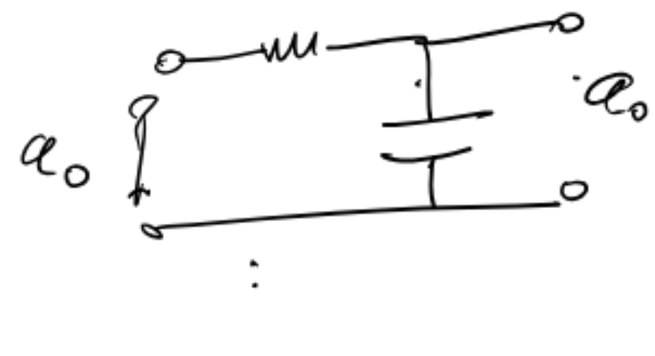
Filtro smorzare tutte Armoniche !!!

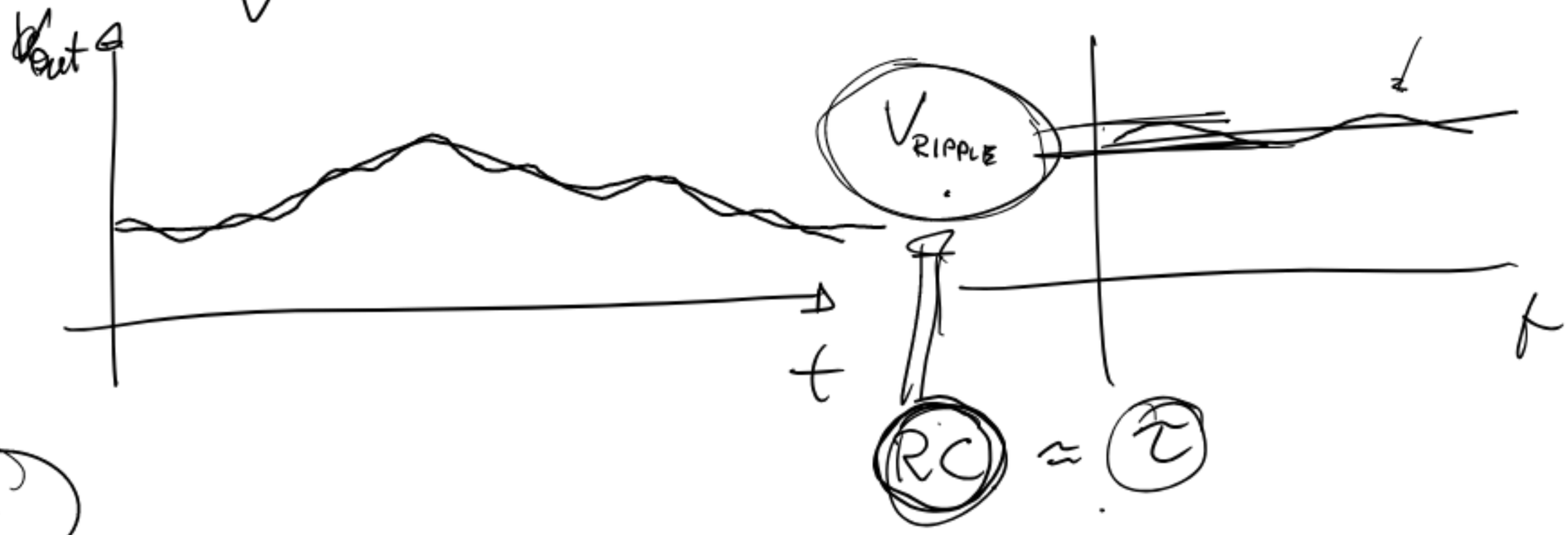


$$f(t) = a_0 + \sum \text{armoniche}$$

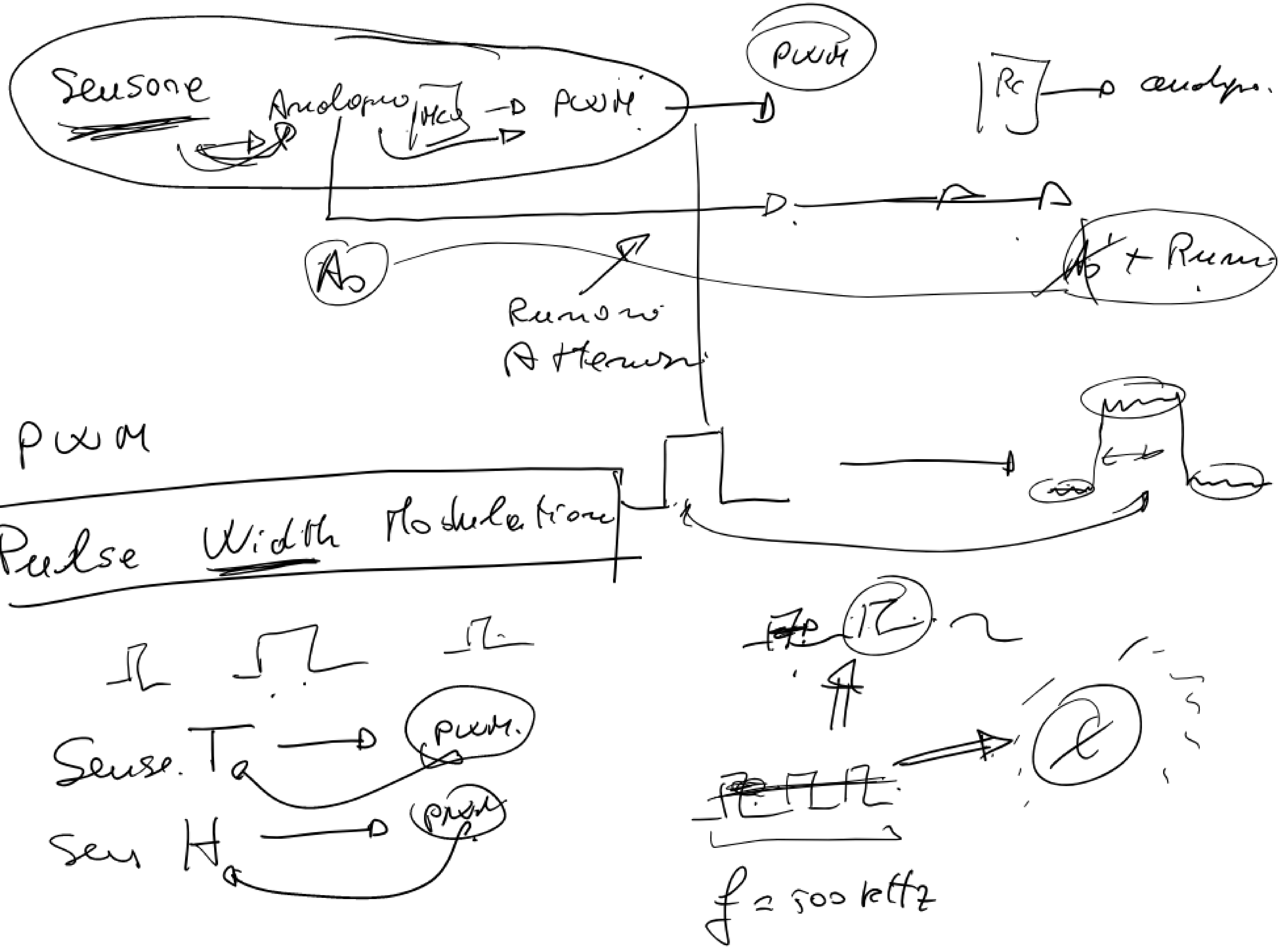
$$a_0 = \frac{1}{T}\int_0^T f(t)\,dt$$

RC



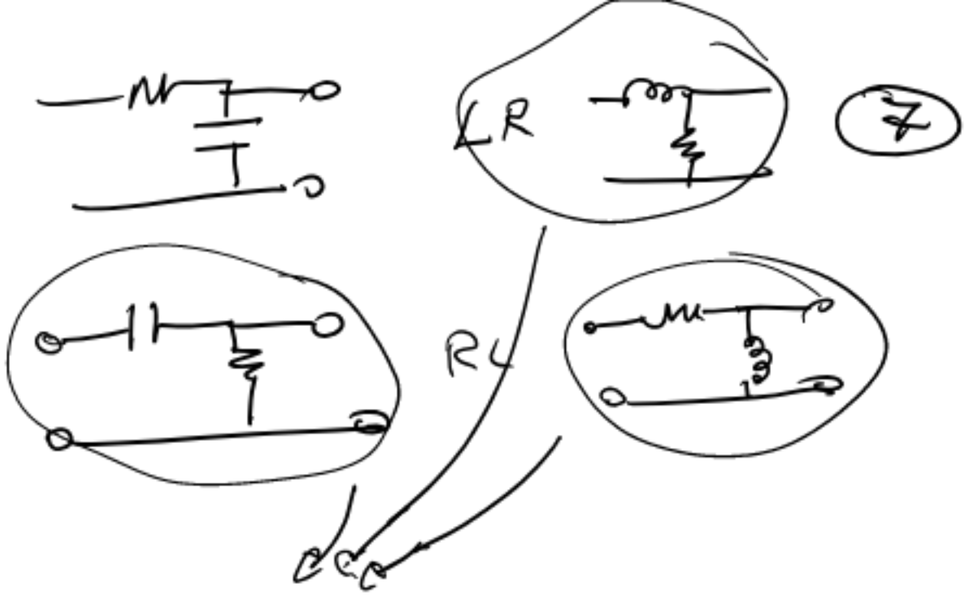


Temp


Sensore
Analogico
MCU
PWM
PWM
Rc
analogico
A0
Rumori
Attenuazione
A0' + Rumori
PWM
Pulse Width Modulation
Sense. T
pwm
Sen H
pwm
f = 500 kHz

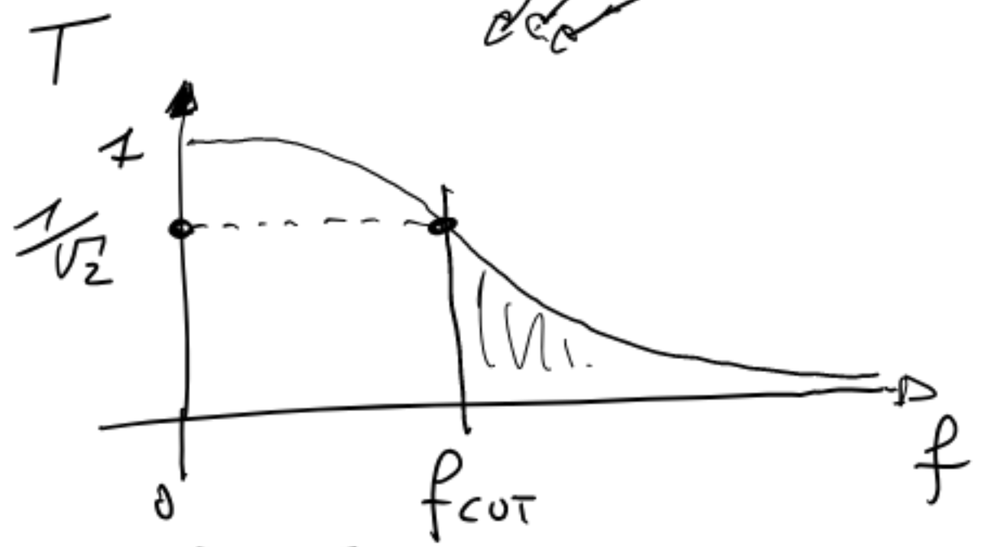
RC — FILTRO PASSA BASSO

CR — " PASSA ALTO



RC

$$T = \frac{1}{\sqrt{1 + (2\pi f RC)^2}}$$



Def f_{cut}

$$T = \frac{1}{\sqrt{2}} \approx 0,70\ldots = 70\%$$

$$2\pi f RC = 1$$

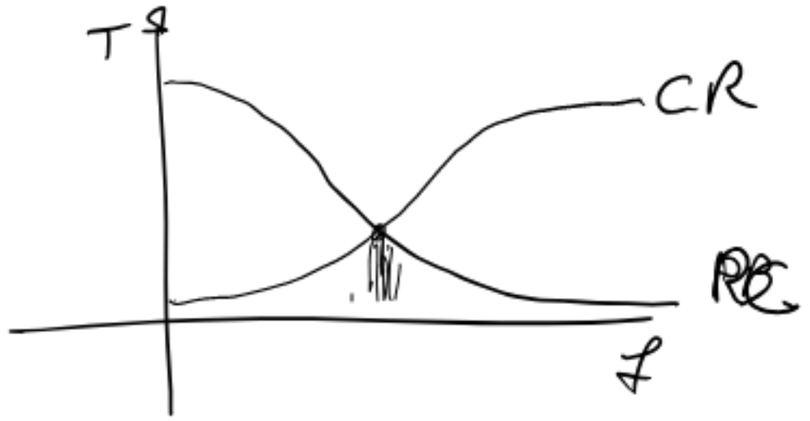
$$\boxed{f_{cut} = \frac{1}{2\pi RC}}$$

CR PASSA ALTO

$$T = \frac{1}{\sqrt{1 + \left(\frac{1}{\omega RC}\right)^2}} = \begin{cases} \omega \to 0 \Rightarrow 0 \\ \omega \to \infty \Rightarrow 1 \end{cases}$$

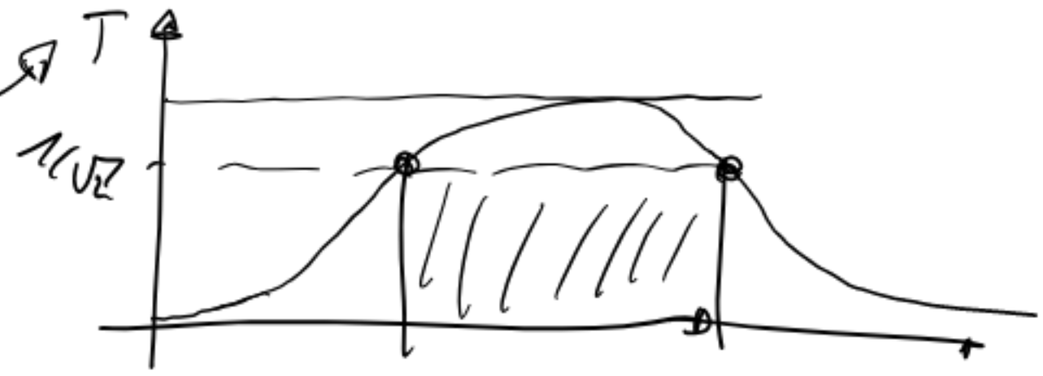
PASSA ALTO

- RC passa basso
- CR passa alto



PASSA BANDA ?

× $f_{MIN} \div f_{MAX}$ ×



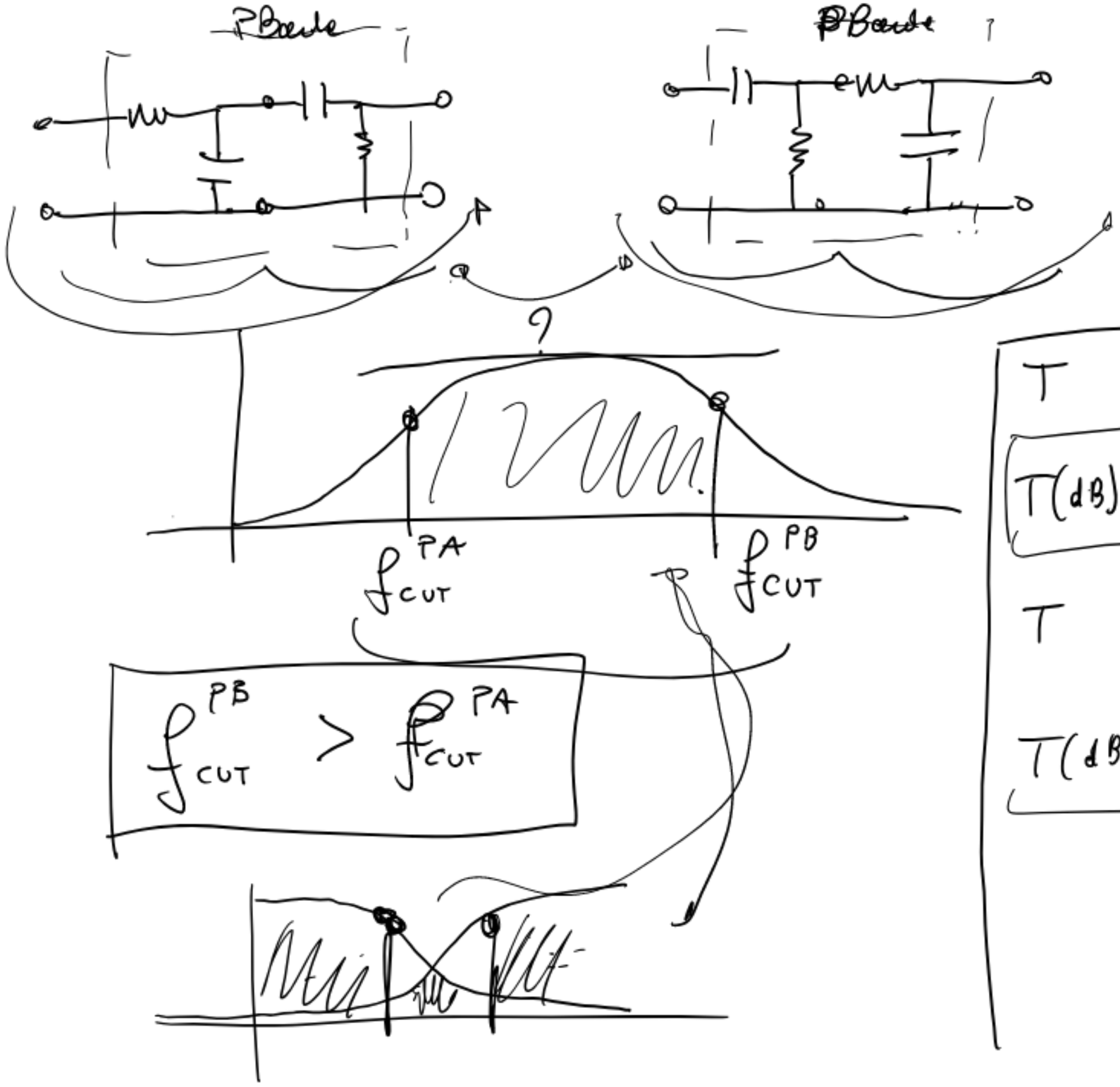
$f_{SIG} = 1$ kHz

$f_{EL} = 50$ Hz

$f_{CELL} \simeq$ MHz

PASSA BANDA

RC + CR



T dB

$T(dB) = 10 \cdot \log_{10}(T)$

T dB 0 ↓

$T(dB) \simeq -1,5$