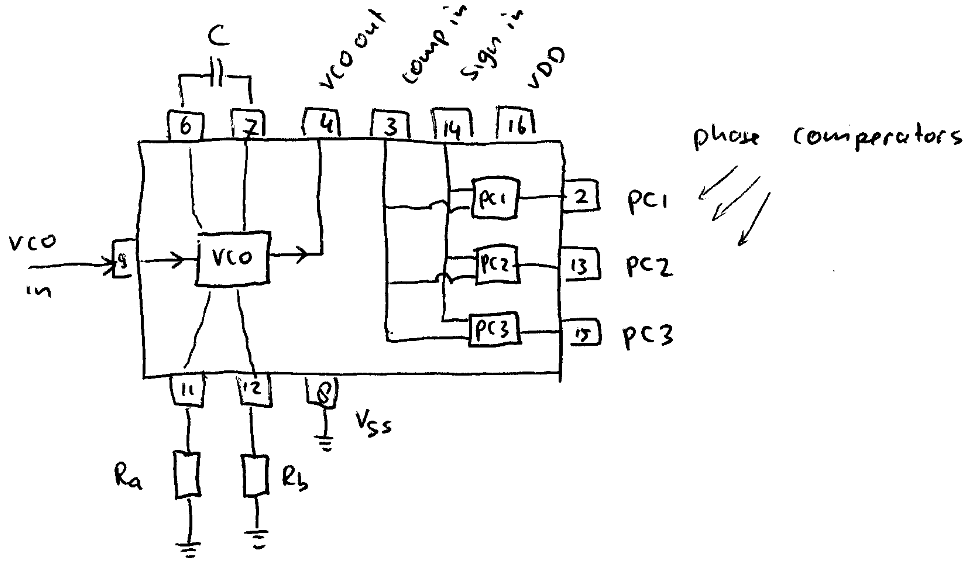
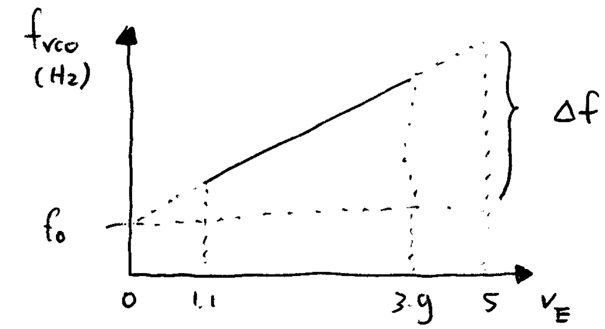
Electrónica III Folha de problemas 9 0/5

DATASHEET DE 4046 A PLL



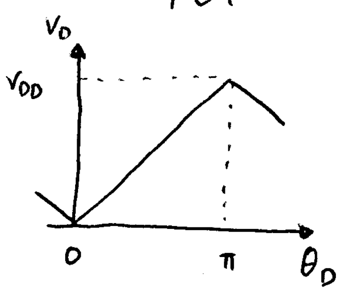
VCO :



$$f_o = \frac{1}{2\pi R_b C} \quad , \quad \Delta f = \frac{1}{2\pi R_a C}$$

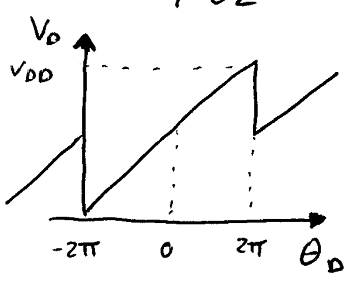
Phase comparators:

PC1



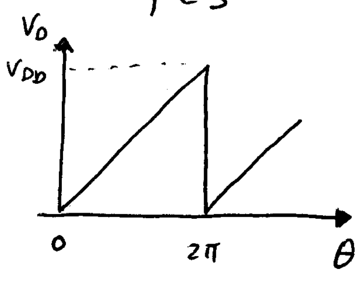
- duty cycle 50% !

PC2



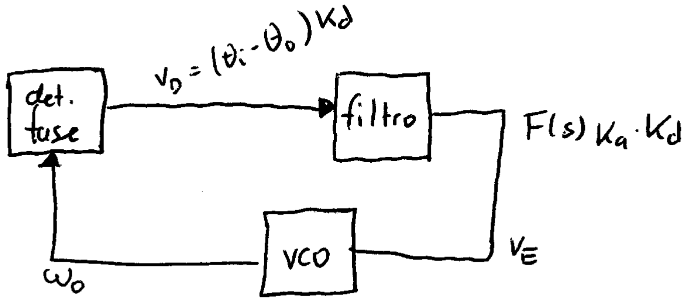
- any duty cycle
- clean signals !

PC3



- any duty cycle

1)



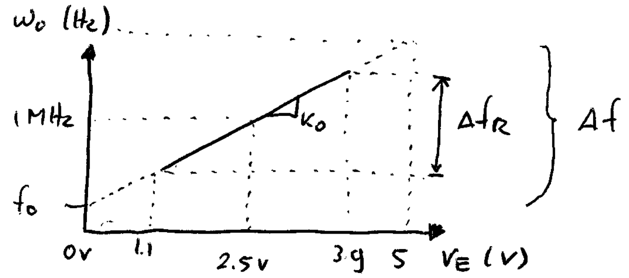
DATASHEET DE PLL 4046A VEJA p. 0

$$\omega_o = K_o V_E + f_o$$

* alimentação : 0 V e +5V (= V_{DD})

  (todos os sinais devem ser entre 0V e +5V)

  (mas: nota que V_E deve ficar entre 1.1 V e 3.9 V, veja p.4)
* VCO : f- central = 1.0 MHz
* filtro: "Lag lead"



Δf_R deve incluir a 20 kHz de modulação.

vamos usar Δf_R = 500 kHz $\Rightarrow K_o = \frac{d\omega_o}{dV_E} = \frac{2\pi \cdot 500 \cdot 10^3 \text{ rad/s}}{(3.9 - 1.1)\text{ V}}$

$$K_o = 1.1\ 10^6 \text{ rad/s·V}$$

$$f_o = 1\text{ MHz} - \frac{2.5}{2.8} \cdot 500\text{ kHz} = 553.6\text{ kHz}$$

$$\Delta f = 2 \times (1\text{ MHz} - f_o) = 892.9\text{ kHz}$$

$$R_b = \frac{1}{2\pi f_o \cdot C} = 2.87\ k\Omega$$

$$R_a = \frac{1}{2\pi \Delta f \cdot C} = 1.78\ k\Omega$$

C = 100 pF (escolha)

* Detector de phase :

Usamos <u>PC1</u> (temos sinais "sujo" com duty cycle de 50%)

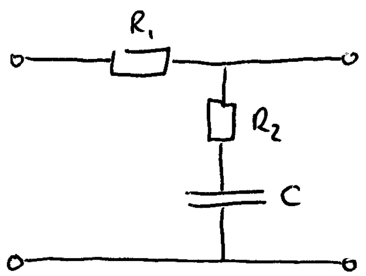
$$K_d = \frac{V_{DD}}{2\pi} = \frac{5}{\pi}\ V/rad$$

$$K_v = K_a \cdot K_o \cdot K_d = 1 \cdot \left(\frac{5}{\pi}\ V/rad\right) \cdot (1.1\ 10^6\ rad/Vs) \cdot$$

$$= 17.51\ 10^5\ s^{-1}$$

(o filtro e do tipo "lag-lead" e é passivo $\Rightarrow K_a = 1$)

* Filtro lag-lead



$$F(s) = \frac{1 + s/\omega_z}{1 + s/\omega_p}$$

$$\omega_z = \frac{1}{R_2 C}$$

$$\omega_p = \frac{1}{(R_1 + R_2) C}$$

(B)

Forma geral para malha fechada :

$$H(s) = \frac{(2\zeta - \omega_n/K_v)(s/\omega_n) + 1}{(s/\omega_n)^2 + 2\zeta(s/\omega_n) + 1}$$

("damped oscillator")

$$\omega_n = \sqrt{\omega_p K_v} \qquad \zeta = \frac{\omega_n}{2\omega_z}\left(1 + \frac{\omega_z}{K_v}\right)$$

(A)

- $\tau = \frac{1}{\omega_n}$ (tempo de relax.)
- largura da banda :

$$\omega_{3dB} = \omega_n \left[1 \pm 2\zeta^2 + \sqrt{1 + (1 \pm 2\zeta^2)^2}\right]^{1/2}$$

Minimizar "overshoot" ()

$$0.5 \leq \zeta \leq 1$$

por exemplo : $\zeta = \frac{1}{\sqrt{2}} \Rightarrow \omega_{3dB} = \omega_n$

queremos que $\omega_n > 2\pi f_m$ $(f_m = 1\ kHz)$

exemplo : $\omega_n = 2\pi \cdot 10\ kHz$

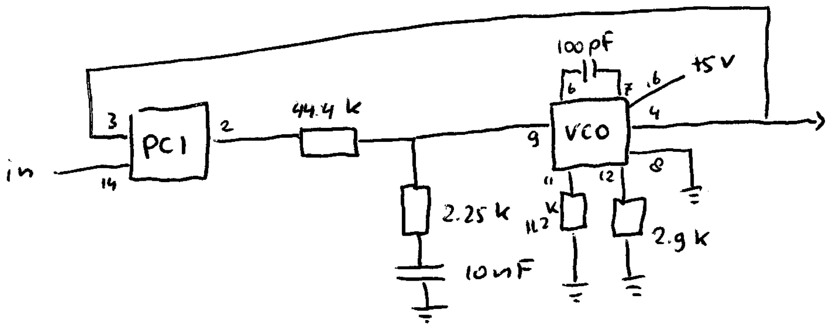
(A) $\Rightarrow$ $\omega_p = \frac{\omega_n^2}{K_v} = 2.25$ krad/s

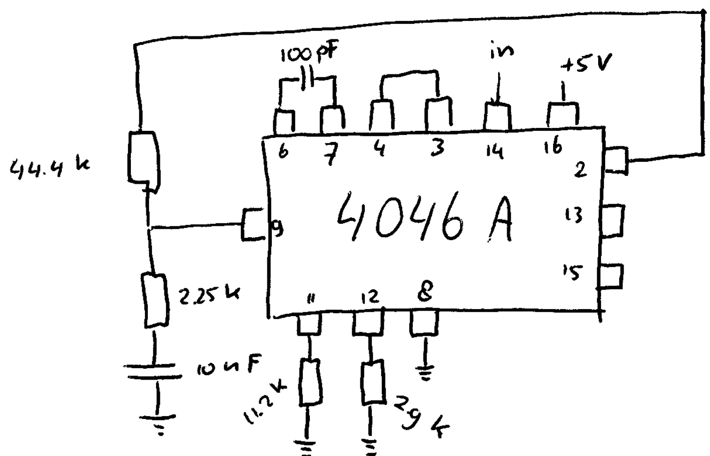
$$\omega_z \approx \frac{\omega_n}{2\zeta} = 44.4 \text{ krad/s}$$

(B) $\Rightarrow$ $R_2 = \frac{1}{\omega_z C} = 2.25\ k\Omega$

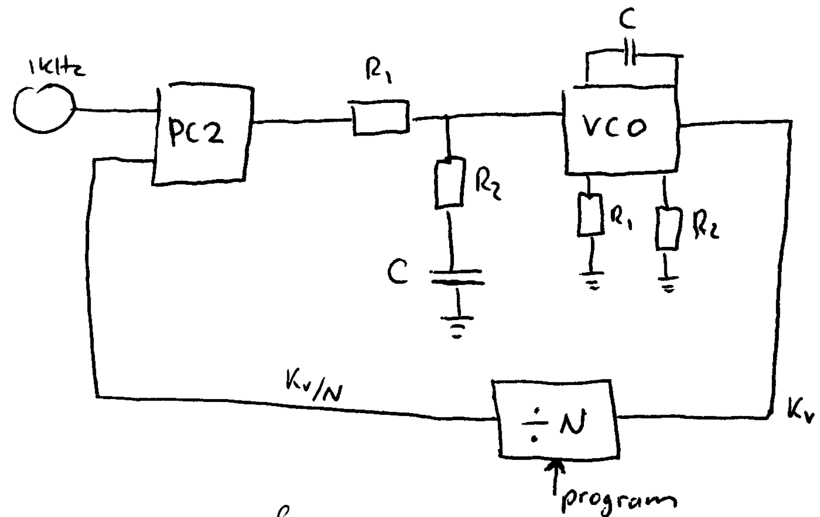
$C = 10\ nF$ (escolha)

$$R_1 = \frac{1}{\omega_p C} - R_2 = 44.4\ k\Omega$$

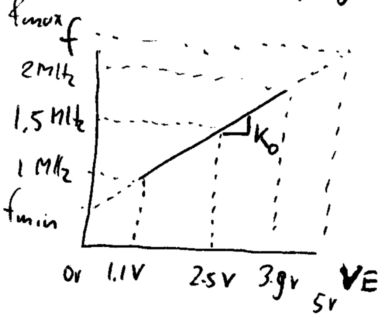




2)



VCO:



$$K_o = \frac{df}{dv_E} = \frac{2\,MHz - 1\,MHz}{3.9\,V - 1.1\,V} = 3.57\ 10^5\ Hz/V$$

$$f_{min} = -\frac{(2.5-0)}{(2.5-1.1)} \cdot (1.5\,MHz - 1\,MHz) + 1.5\,MHz = 0.60\ MHz$$

$$f_{max} = 2.4\ MHz$$

$$\Delta f = 2.4\ MHz - 0.6\ MHz = 1.8\ MHz = \frac{1.5V}{R_1 C}$$

$$f_o = 0.6\ MHz = \frac{1}{R_2 C}$$

exemplo: $C = 110\ pF \Rightarrow R_2 = 15.1\ k\Omega$

$R_1 = 25.3\ k\Omega$

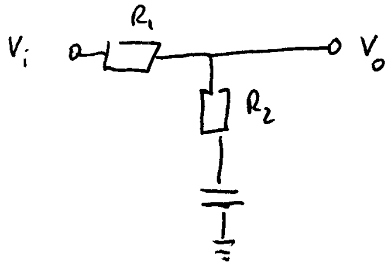
PC2 é para sinais "limpos" (bom neste casu)
com "duty cycle" < 100%

$$K_d = \frac{V_{DD}}{4\pi} = \frac{5}{4\pi}\ V\,rad^{-1}$$

$$K_v = K_o \cdot K_d = 1.42\ 10^5\ s^{-1}\,rad^{-1}$$

$$\frac{K_v}{N} \approx 1000\ s^{-1}rad^{-1} \quad (\bar{N} = 1414) \qquad \bar{N} = \sqrt{N_{max} N_{min}}$$

Filtro Lag lead :



$$\zeta = \frac{1}{\sqrt{2}} = \frac{\omega_n}{2\omega_z}$$

$$\omega_n = 2\pi \cdot 100 \text{ Hz} = \sqrt{\omega_p K_v}$$

$$\omega_z = \frac{\omega_n}{2\zeta} = \frac{2\pi \cdot 100}{2 \cdot \frac{1}{\sqrt{2}}} = 444.2 \quad \text{rad/s}$$

$$\omega_p = \frac{\omega_n^2}{K_v/N} = \frac{(2\pi \cdot 100)^2}{1000} = 394.8 \quad \text{rad/s}$$

$$\omega_p = \frac{1}{(R_1+R_2)C}$$

$$\omega_z = \frac{1}{R_2 C}$$

$$C = 1\ \mu\text{F} \implies R_2 = 2.251\ \text{k}\Omega$$

$$R_1 = 282\ \Omega$$