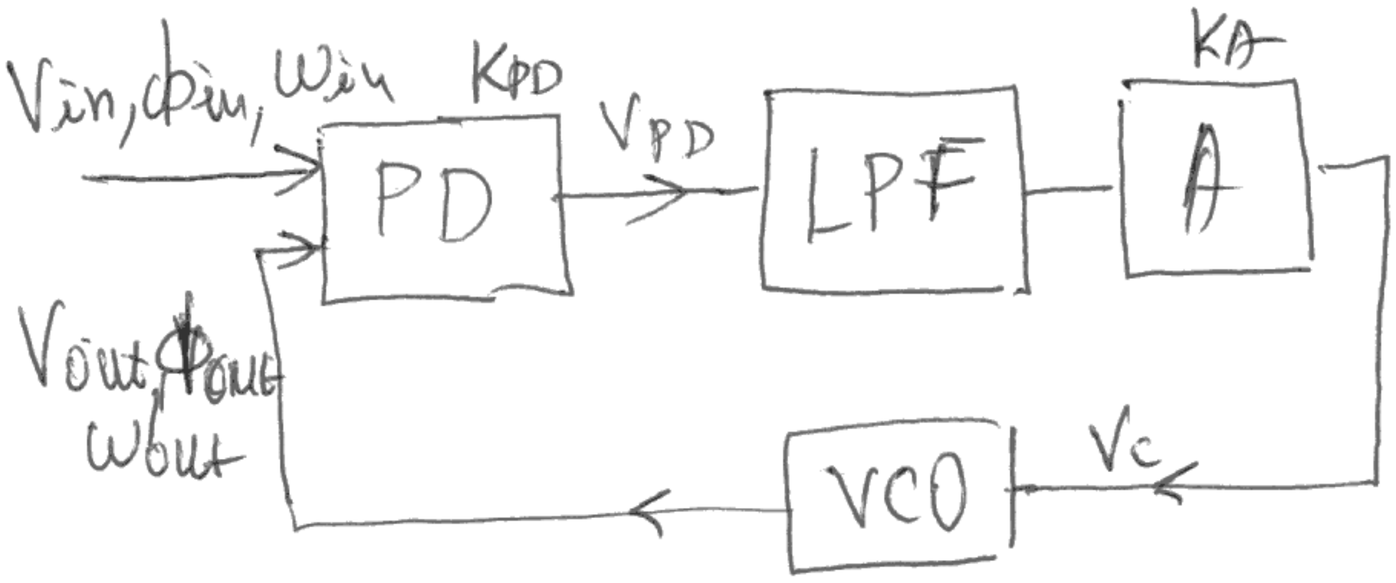
1) U kolu fazno zatvorene petlje poznato je: pojačanje faznog detektora kd=2 V/(rad/s), pojačanje pojačavača ka=50, pojačanje naponom kontrolisanog oscilatora Kvco=100 Hz/V, frekvencija slobodnog oscilovanja f_0=100 kHz. Odrediti:
   a. Opseg hvatanja fazno zatvorene petlje, $\Delta\omega_H$.
   b. Odrediti napon greške Vpd, kontrolišući napon Vc i statičku faznu grešku kada je frekvencija ulaznog signala fs=100.5 kHz.



a)

$\omega_{out} = \omega_0 + K_{VCO} \cdot V_c$

ω_0 – frekvencija slobodnog oscilovanja

$V_C = V_{PD} \cdot F(\phi) \cdot K_A = V_{PD} \cdot K_A$

$V_{PD} = K_{PD} \cdot \cos(\phi_{in} - \phi_{out})$

$V_{PD\,max} = K_{PD}$

$\omega_0 - K_{VCO} \cdot K_{PD} \cdot K_A < \omega_i < \omega_0 + K_{VCO} \cdot K_{PD} \cdot K_A$

$\omega_0 - \Delta\omega_H < \omega_i < \omega_0 + \Delta\omega_H$

$\Delta\omega_H$ – opseg hvatanja

$\Delta\omega_H = K_{VCO} \cdot K_{PD} \cdot K_A \cdot F(0) = 200 \cdot \pi \frac{\frac{rad}{s}}{V} \cdot 2 \frac{V}{rad} \cdot 50$

$\Delta\omega_H = 20\,000 \cdot \pi \frac{rad}{s}$ $\quad \Delta f_H = 10\ kHz$

b) $f_s = 100{,}5\ KHz$

$f_0 = 100\ KHz$

фр. сигнала је унутар опсега хватања

$$f_{out} = f_0 + K_{VCO} \cdot V_C$$

$$V_C = \frac{1}{K_{VCO}} (f_{out} - f_0) = \frac{500Hz}{100\ \frac{Hz}{V}} = 5V$$

V_C – контролишући напон

$$V_C = K_{PD} \cdot K_A \cdot F(\theta)$$

$$V_{PD} = \frac{V_C}{K_A \cdot F(\theta)} = \frac{5V}{50} = 0{,}1V$$

V_{PD} – напон грешке

$$V_{PD} = K_{PD} \cdot \sin(\theta_{out} - \theta_{in}) = K_{PD} \cdot \sin(\phi_{out} - \phi_{in})$$

$$\phi_{in}(t) = \omega_s \cdot t + \theta_{in}$$

$$\phi_{out}(t) = \omega_s \cdot t + \theta_{out}$$

$$V_{PD} = K_{PD} \cdot \sin(\theta_{in} - \theta_{out})$$

$$V_{PD} = K_{PD} \cdot \sin \Delta\theta$$

$$\Delta\theta = \arcsin \frac{V_{PD}}{K_{PD}}$$

за $\Delta\theta \ll 1$

$$V_{PD} \approx K_{PD} \cdot \Delta\theta$$

$$\Delta\theta = \frac{V_{PD}}{K_{PD}} = 0{,}05\ rad$$

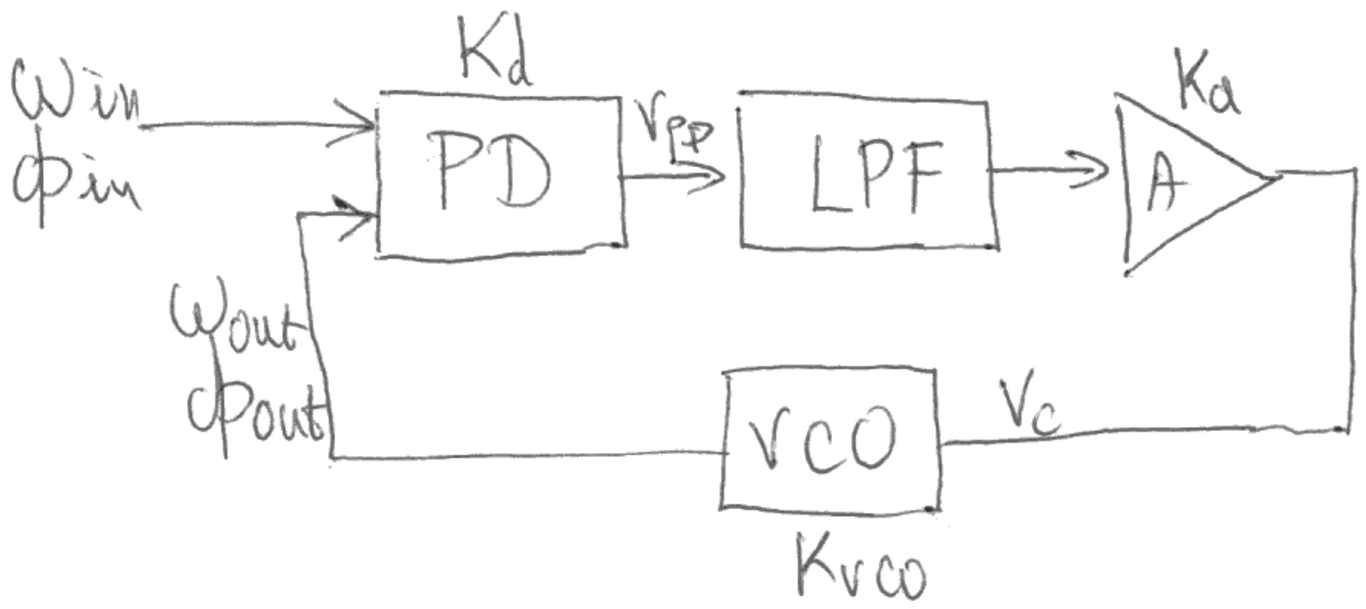
статичка фазна грешка

2) U kolu fazno zatvorene petlje poznato je: pojačanje faznog detektora kd=2 V/(rad/s), pojačanje pojačavača ka=10, pojačanje naponom kontrolisanog oscilatora K_{vco}=100 Hz/V, frekvencija slobodnog oscilovanja f_0=100 kHz. Odrediti opseg hvatanja fazno zatvorene petlje kada je:

   a. Fazni dektetor sa kosinusnom prenosnom karakteristikom.

   b. Fazni detektor sa trougaonom prenosnom karakteristikom.

   c. Fazni detektor sa testerastom prenosnom karakteristikom.



a) Pojačanje u otvorenoj petlji K_{OL},

$$K_{OL} = K_d \cdot K_a \cdot K_{vco} \cdot \sin\theta_e$$

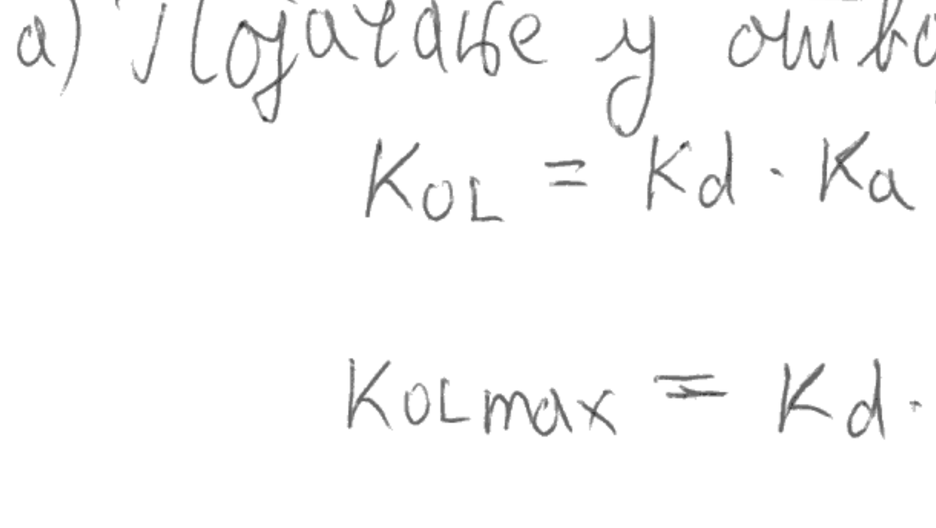
$$K_{OLmax} = K_d \cdot K_a \cdot K_{vco} = 2\frac{V}{rad} \cdot 10 \cdot 2\pi \cdot 100\frac{\frac{rad}{s}}{V}$$

$$K_{OLmax} = 4000 \cdot \pi \frac{rad}{s}$$

$$\Delta\omega_H = \pm K_{OLmax} = \pm 4000\pi\frac{rad}{s}$$

$$\Delta f_H = \pm 2000\,Hz$$ – Opseg hvatanja

b)



$$K_{OL} = K_d \cdot K_a \cdot K_{vco} \cdot \theta_e$$

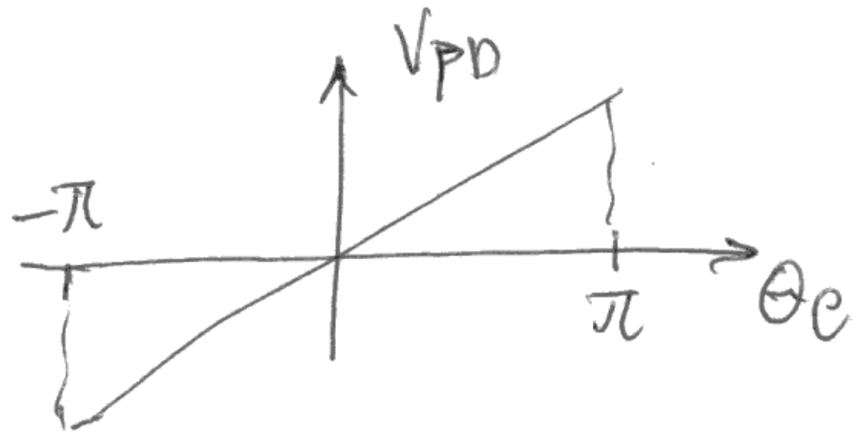
$$K_{OLmax} = K_d \cdot K_a \cdot K_{vco} \cdot \frac{\pi}{2}$$

$$K_{OLmax} = 2\frac{V}{rad} \cdot 10 \cdot 100 \cdot 2\pi\frac{\frac{rad}{s}}{V} \cdot \frac{\pi}{2}$$

$$\Delta \omega_H = \pm K_{OL\,max} = \pm 19\,719 \frac{rad}{s}$$

$$\Delta f_H = \pm 3140\ Hz$$

c)



$$K_{OL} = K_d \cdot K_0 \cdot K_a \cdot \theta_e$$

$$K_{OL\,max} = K_d \cdot K_0 \cdot K_a \cdot \pi$$

$$K_{OL\,max} = 12560 \cdot \pi \frac{rad}{s}$$

$$\Delta \omega_H = \pm K_{OL\,max} = \pm 12560 \frac{rad}{s}$$

$$\Delta f_H = \pm 6280\ Hz$$