Resolução (compacta):

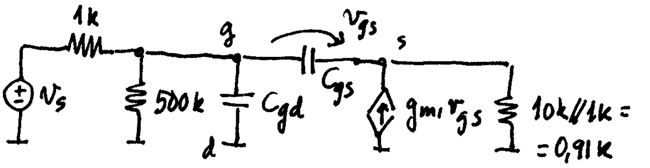
a) zero duplo na origem

$$\omega_1 = \frac{1}{1\mu \times 501k} \cong 2 \text{ rad/s} \qquad \omega_0 = \frac{1}{50\mu \times 2k7} = 7{,}4 \text{ rad/s} \qquad r_\pi = \frac{\beta_0}{g_{m2}} = 1 \text{ k}\Omega$$

$$\omega_2 = \frac{1}{50\mu \times \left(2k7 \,//\, \frac{1k + 10k//(1/g_{m1})}{\beta_0 + 1}\right)} = 1{,}92 \text{ krad/s} \qquad \omega_3 = \frac{1}{1\mu \times 12k7} = 78{,}7 \text{ rad/s}$$

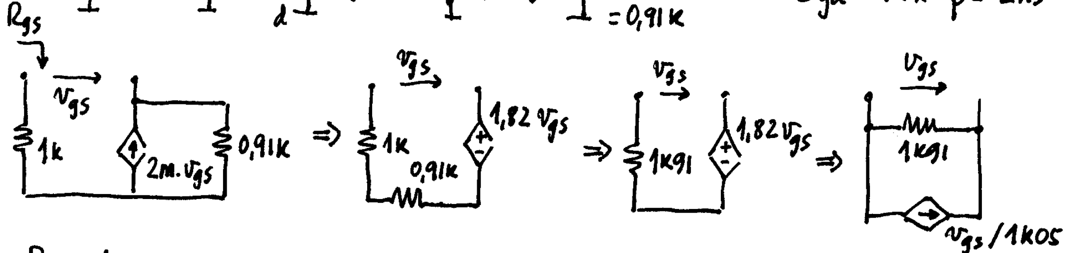
ω_2 é dominante $\Rightarrow \omega_L \cong \omega_2 = 1{,}92$ krad/s

b)



$R_{gd} = 1k // 500k \cong 1 \text{k}\Omega$

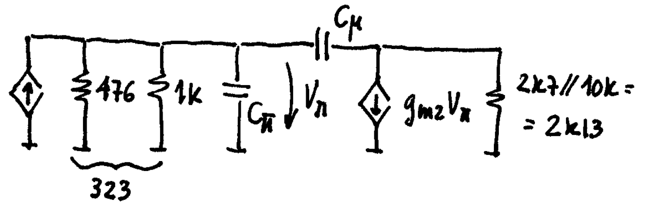
$\tau_{gd} = 1k \times 2p = 2 \text{ns}$



$R_{gs} = 1k05 // 1k91 = 677 \ \Omega \Rightarrow \tau_{gs} = 677 \times 3p = 2{,}03$ ns

$\tau_1 = \tau_{gd} + \tau_{gs} = 4{,}03$ ns

c)



$\frac{1}{g_{m1}} // 10k = 476 \ \Omega$

$K = -g_{m2} \cdot 2k13 \cong -298$

$\tau_i = 323(C_\pi + C_\mu(1-K)) = 128{,}6$ ns $\qquad \tau_o = 1p \times 2k13 = 2{,}1$ ns

$\tau_2 = \tau_i + \tau_o = 130{,}7$ ns

d)

$b_1 = \tau_1 + \tau_2 \cong 134{,}8$ ns 3 cond. indep. $\Rightarrow$ 3 pólos, 1 zero no infinito $\Rightarrow$ $\Rightarrow$ 2 zeros finitos. É fácil ver que os zeros são de muito alta frequência: $s_{01} = -g_{m1}/C_{gs}$ e $s_{02} = g_{m2}/C_\mu$. Tendo em conta que a τ associada à capacidade de Miller do EC domina claramente, seguramente $\omega_H \cong \omega_1 \cong \frac{1}{b_1} \cong$ $\cong 7{,}42$ Mrad/s. O cálculo de b_2 poderia comprovar a estimativa...

Ganho às médias:

$\frac{500k}{501k} \cong 1 \Rightarrow A_v \cong A_1 \cdot A_2$

$$A_1 = \frac{10k//1k}{1/g_{m1} + 10k//1k} = 0{,}645$$

$A_2 = -g_{m2} \cdot 2k13 \cong -298$

$A_v \cong -192$ V/V $\Rightarrow 45{,}7$ dB