EHB 335E - HOMEWORK II - SOLUTIONS - ALİCAN ÇAĞLAR

①

$$H(s)=\frac{4(20+s)(20000+s)}{(200+s)(2000+s)}=\frac{4\cdot\left(1+\frac{s}{20}\right)\cdot\cancel{20}\left(1+\frac{s}{20000}\right)\cdot\cancel{20000}}{\left(1+\frac{s}{200}\right)\cancel{200}\left(1+\frac{s}{2000}\right)\cancel{2000}}=\frac{4\cdot\left(1+\frac{s}{20}\right)\left(1+\frac{s}{20000}\right)}{\left(1+\frac{s}{200}\right)\left(1+\frac{s}{2000}\right)}$$

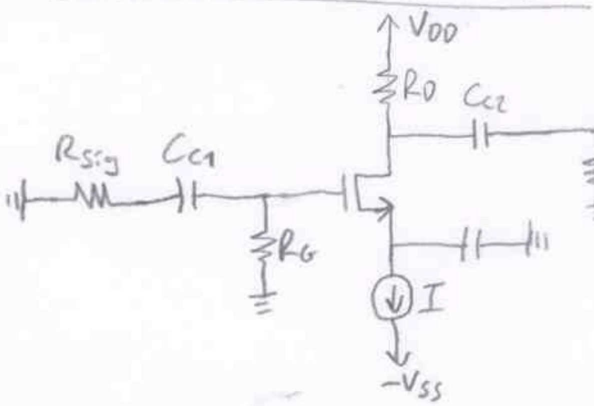
$\omega_{z1}=20,\quad \omega_{z2}=20000,\quad \omega_{p1}=200,\quad \omega_{p2}=2000$

$\omega_0=0 \rightarrow H(0)=4 \rightarrow |H(0)|_{dB}=20\log 4\cong 12\ dB$

→ Bode graphs are on half logaritmic paper at the end of solutions.

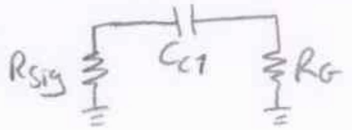
②

Step 1: Set the input signal $V_{sig}=0$



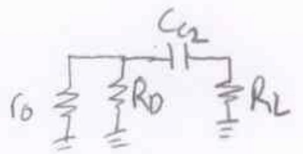
Step 2: Consider one capacitor at a time, and replace the other capacitors with short circuit.

For C_{C1} =>



$$f_{P1}=\frac{1}{2\pi(R_{sig}+R_G)C_{C1}}$$

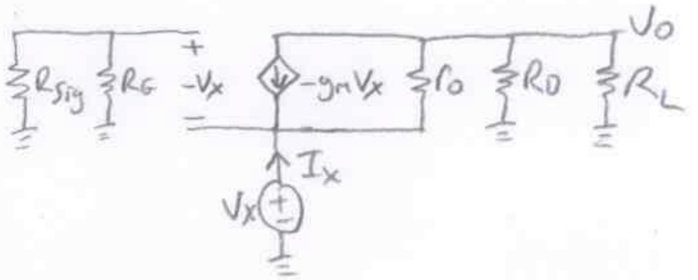
For C_{C2} =>



$$f_{P2}=\frac{1}{2\pi(r_o//R_D+R_L)C_{C2}}$$

For C_S

To determine the total resistance seen by C_S, C_S is replaced by a voltage source V_X.



$$(I_X-g_mV_X)r_o+I_X.R_D//R_L=V_X$$

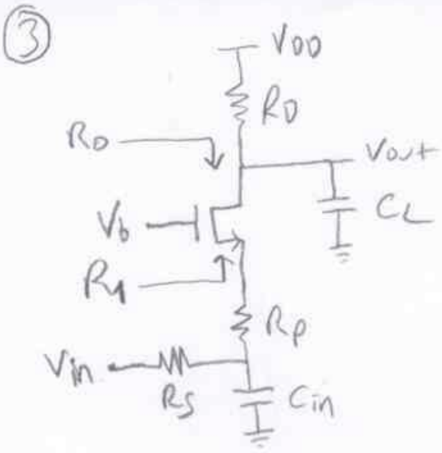
$$R_X=\frac{V_X}{I_X}=\frac{r_o+R_D//R_L}{1+g_mr_o}$$

So, $$f_{P3}=\frac{1}{2\pi C_S.R_X}$$

Step 3: Calculate the 3-dB frequency f_L

$$f_L\simeq f_{P1}+f_{P2}+f_{P3}$$

③



To determine the resistance R_1, we can use the expression of R_X in Question 2.

$$R_1 = \frac{r_o + R_D}{1 + g_m r_o}$$

Then, the resistance R_{eqin} seen by C_{in} will be:

$$R_{eqin} = R_S // (R_P + R_1)$$

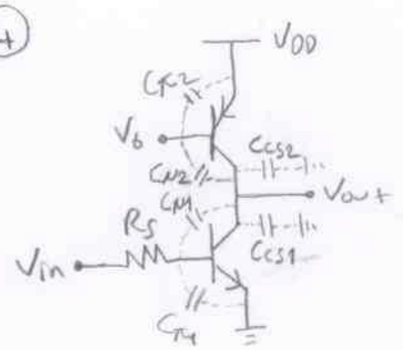
$$\Rightarrow f_{P1} = \frac{1}{2\pi C_{in} . R_{eqin}}$$

$$R_o = g_m r_o R_P + r_o + R_P$$

$$R_{out} = R_o // R_D$$

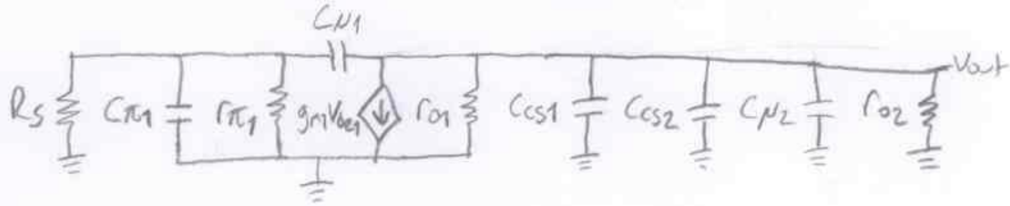
$$f_{P2} = \frac{1}{2\pi C_L R_{out}}$$

④



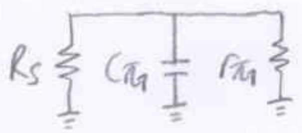
$\Rightarrow$

Step 1: Set the input signal $V_{in} = 0$



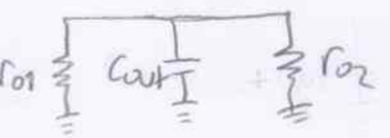
Step 2: Consider one capacitor at a time, and replace other capacitors with open circuit

For $C_{\pi 1}$



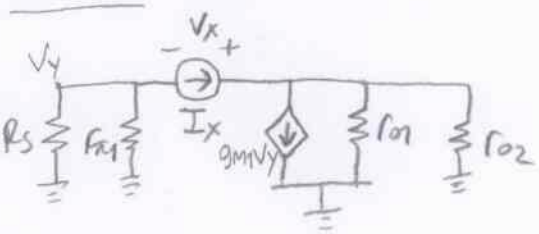
$$\tau_1 = C_{\pi 1}(R_S // r_{\pi 1})$$

For $C_{out} = C_{cs1} + C_{cs2} + C_{\mu 2}$



$$\tau_2 = C_{out} . (r_{o1} // r_{o2})$$

For $C_{\mu 1}$



$$-(R_S // r_{\pi 1}) I_X + V_X - I_X \, r_{o1} // r_{o2} + g_m V_Y . r_{o1} // r_{o2} = 0$$

$$V_Y = -I_X . R_S // r_{\pi 1}$$

$$\Rightarrow R_X = \frac{V_X}{I_X} = g_m (R_S // r_{\pi 1})(r_{o1} // r_{o2}) + R_S // r_{\pi 1} + r_{o1} // r_{o2}$$

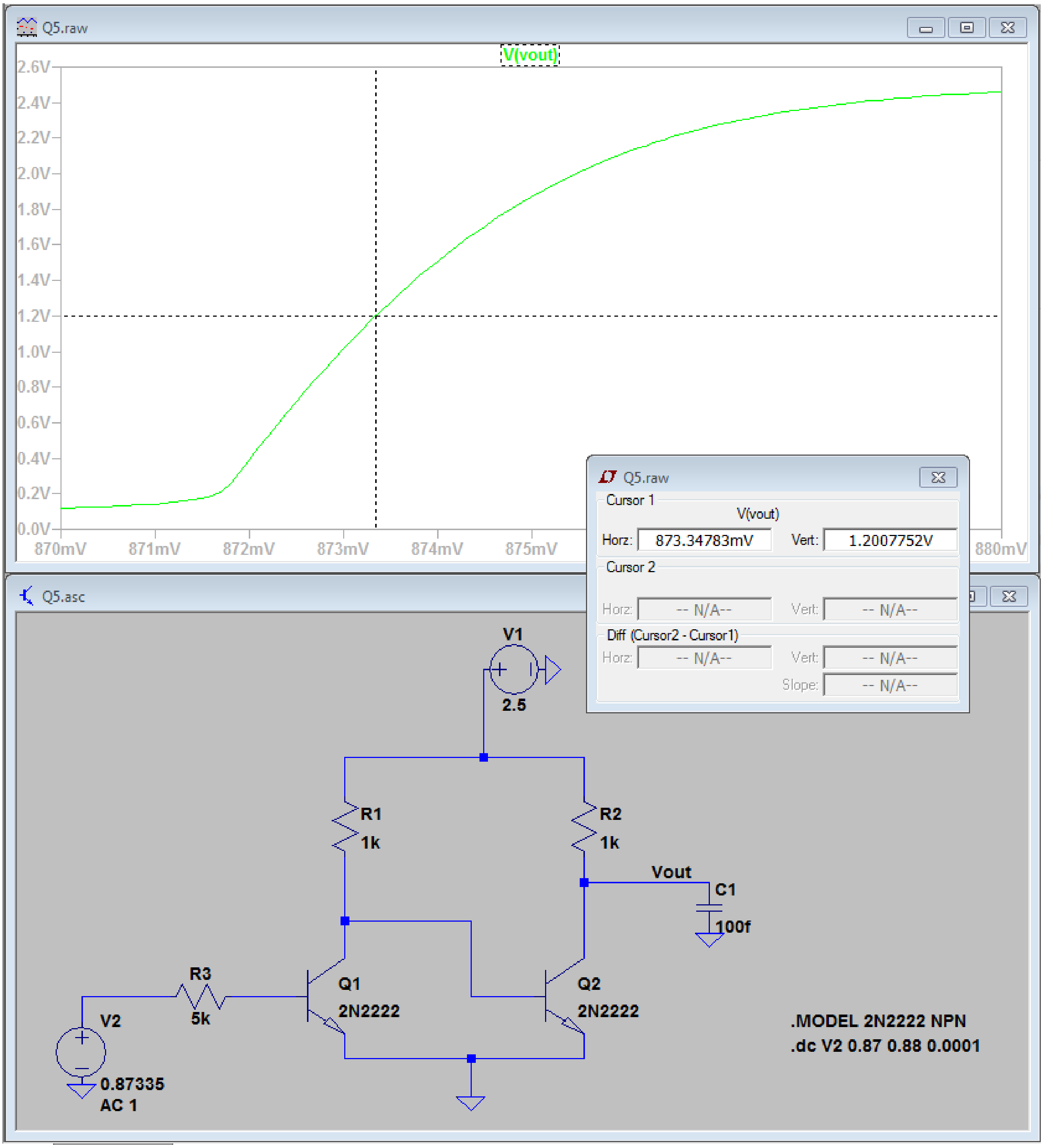
$$\tau_3 = C_{\mu 1} R_X$$

Step 3: Calculate upper corner frequency, f_{-3dB}

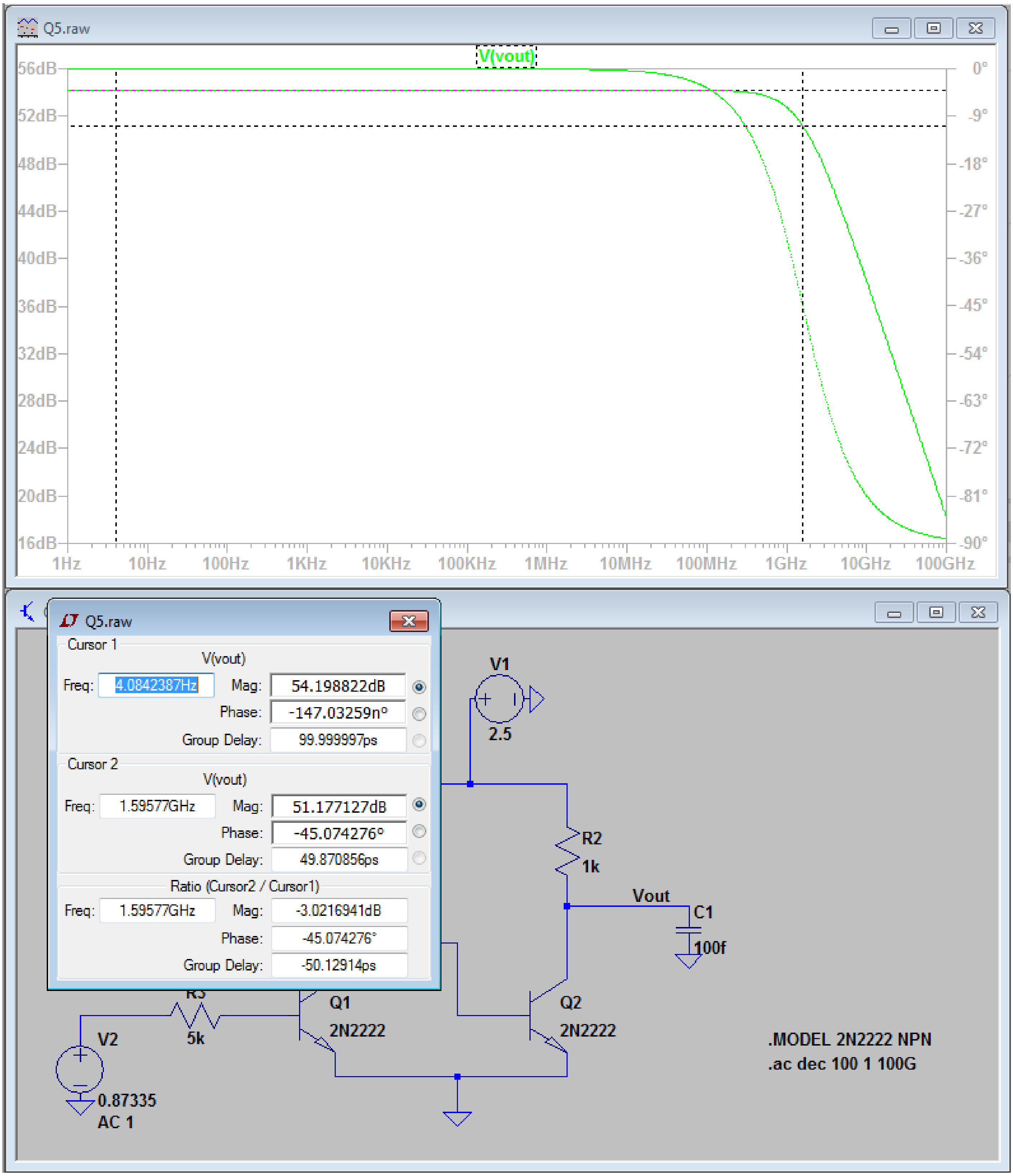
$$f_{-3dB} = \frac{1}{2\pi(\tau_1 + \tau_2 + \tau_3)}$$

5)

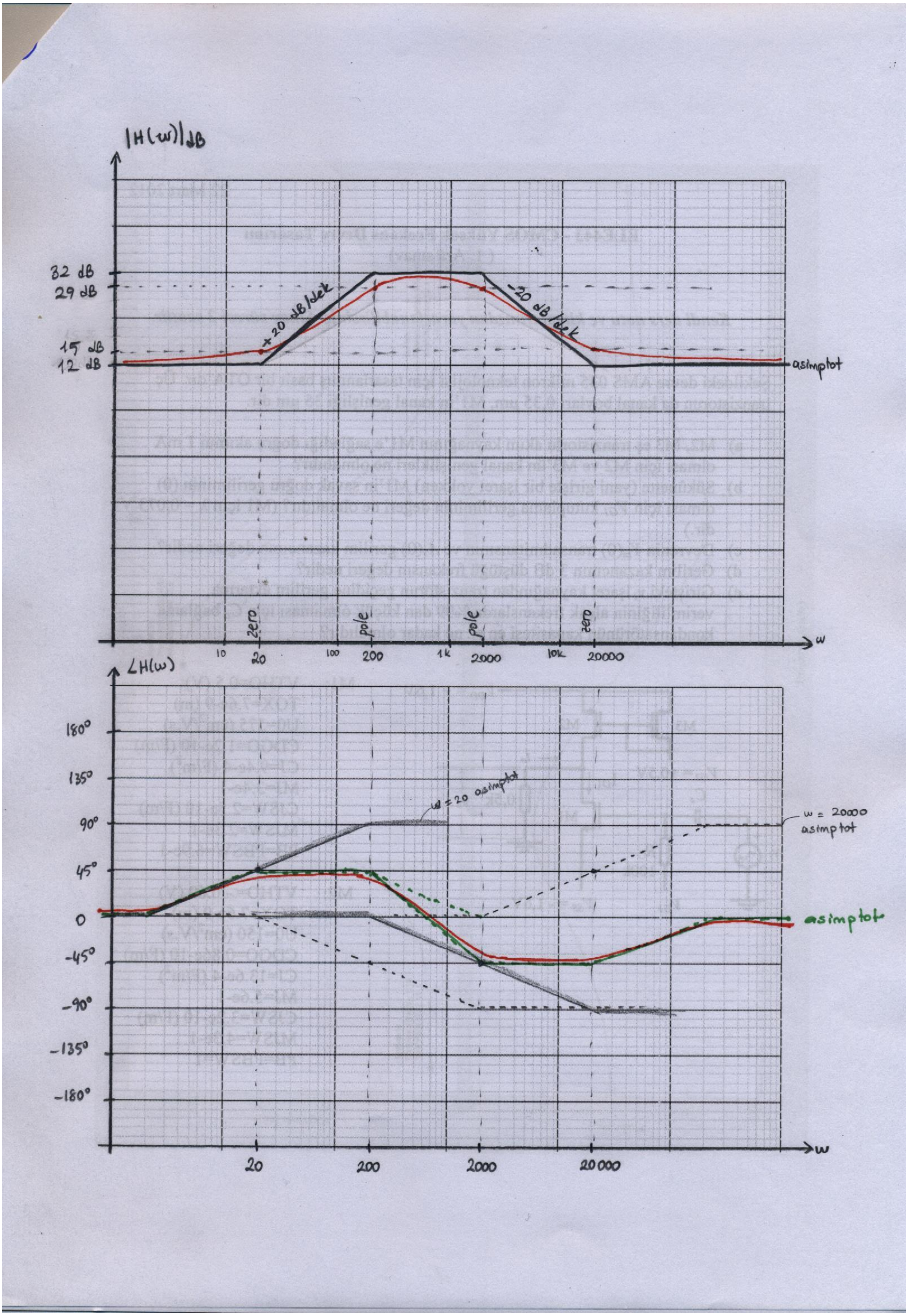
a) DC sweep to determine the input voltage for output DC level of 1.2 V.



b) Frequency Response obtained by AC analysis. Low-frequency gain is 54.2 dB, and -3 dB bandwidth is approximately 1.6 GHz.



Question 1 – Bode Diagrams



Question 1 – MATLAB Simulation Result