Alexandria University
Faculty of Engineering
Electrical Engineering Department

Electronics II: Project

Op-Amp Design

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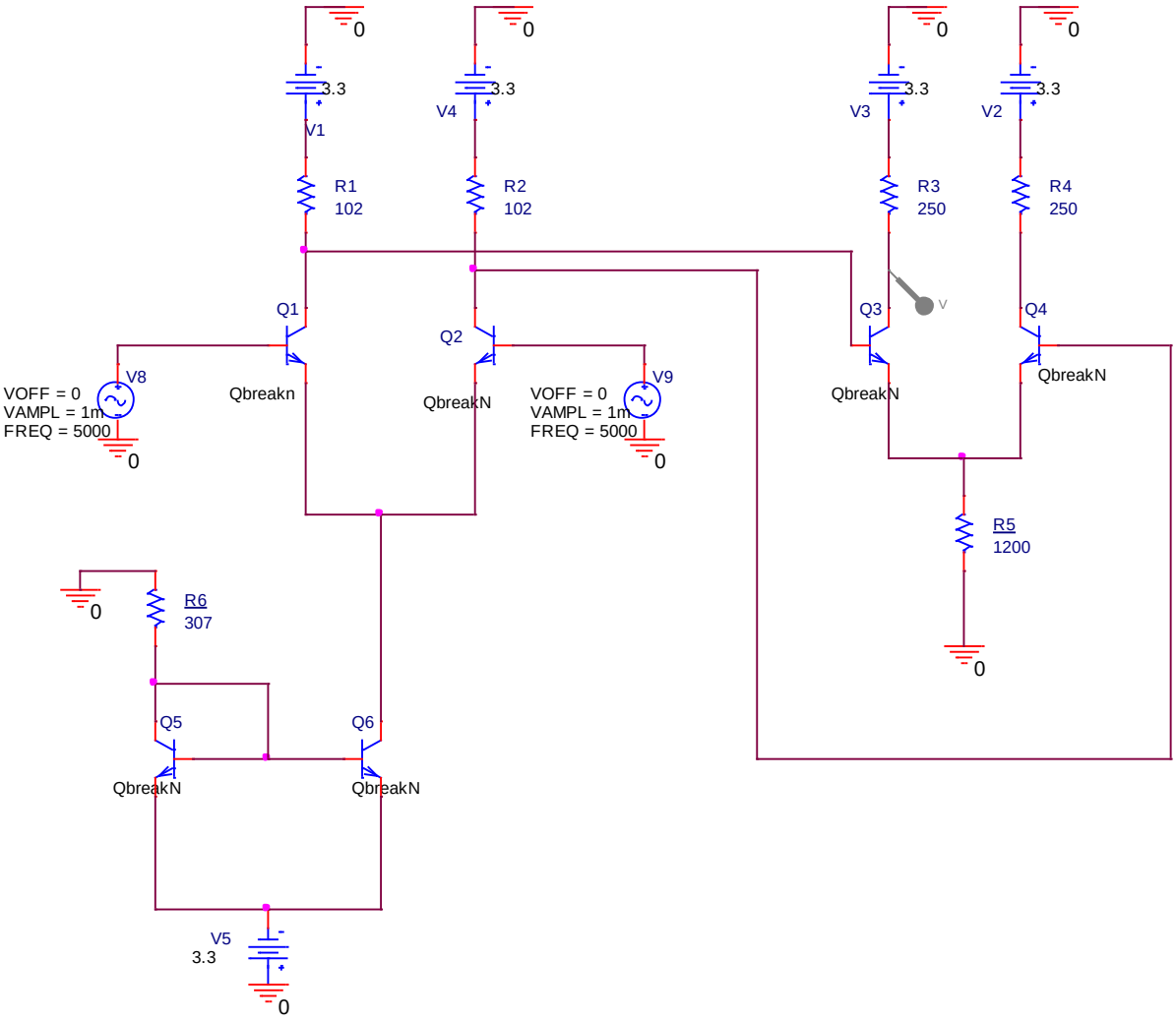
Submitted to: Eng. Nour

Circuit Schematic



The unknowns are:

R1 = R2, R3 = R4, R5, R6

All DC Voltage sources are 3.3 V.

All transistors are NPN BJT transistors.

Hand Analysis

$$\beta = 120,\ C_{jc} = 1pF,\ C_{je} = 10pF$$

$$I_{EE1} = \frac{3.3 - 0.7}{R_6} = \frac{2.6}{R_6}$$

$$I_{c1} = I_{c2} \cong I_{E1} = I_{E1} = \frac{I_{EE1}}{2} = \frac{1.3}{R_6}$$

$$r_{\pi 1} = \beta \frac{25mV}{I_{E1}} = 2.308R_6$$

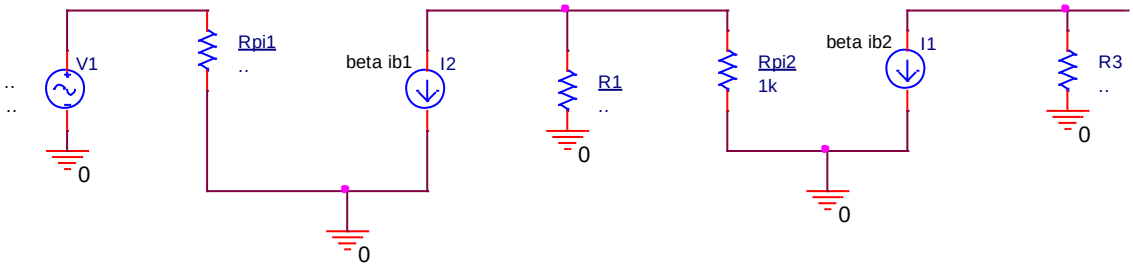
$$V_{c1} = V_{cc} - I_{c1}R_1$$

$$I_{EE2} = \frac{V_{c1} - 0.7}{R_5}$$

$$I_{c3} = I_{c4} \cong I_{E3} = I_{E4} = \frac{I_{EE2}}{2}$$

$$r_{\pi 2} = \beta \frac{25mV}{I_{E3}} = \cdots$$

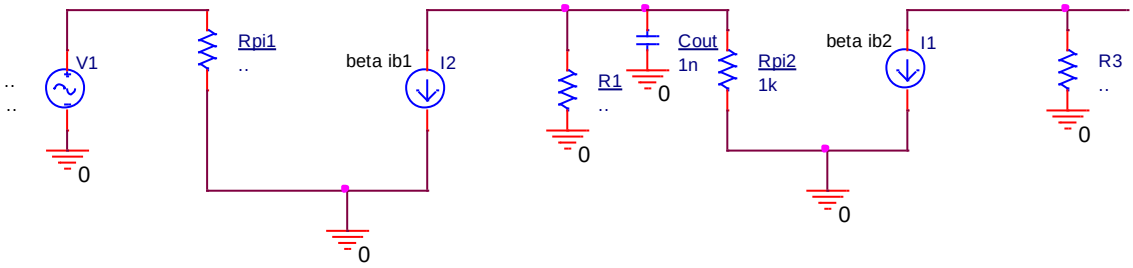
Solving half circuit:



$$A_2 = -\frac{\beta\ ib_3\ R_3}{r_{\pi 2}\ \ ib_3} = -\frac{\beta R_3}{r_{\pi 2}}$$

$$A_1 = -\frac{\beta\ ib_1(R_1//r_{\pi 2})}{ib_1\ r_{\pi 1}} = -\frac{\beta(R_1//r_{\pi 2})}{r_{\pi 1}}$$

$$A_d = A_1A_2 = \frac{\beta^2\ \ R_3\ (R_1//r_{\pi 2})}{r_{\pi 1}\ r_{\pi 2}}$$



$$C_{out} = 1 + \frac{1}{A_1} = 1.0625pF$$

$$\mathrm{f}_{c2} = \frac{1}{2\pi C_{out}(\mathrm{R}_1 // r_{\pi 2})} = \frac{1}{2\pi * 1.0625 * 99} = 1513.059$$

$$\mathrm{f}_{c3} = \frac{1}{2\pi C_{in2}(\mathrm{R}_1 // r_{\pi 2})} = 80MHz$$

$$C_{in2} = c_{je} + c_{jc}(1 + |A_2|) = 20pF$$

$$c_{je} = 10\ pF \quad , c_{jc} = 1\ pF$$

Using the values:

$$R_1 = R_2 = 102\Omega\ , R_3 = R_4 = 250\Omega\ , R_5 = 1200\Omega, R_6 = 307\Omega$$

$$\therefore\ r_{\pi 1} = 708.556\ \Omega \quad , \quad r_{\pi 2} = 3320.91\ \Omega$$

Voltage Gain:

$$A_v = \frac{\beta^2\ R_3\ (R_1 // r_{\pi 2})}{r_{\pi 1}\ r_{\pi 2}} = 151.402$$

Bandwidth:

$$BW = \frac{1}{2\pi * 2 * 10^{-11} * 98.96} = 802786310.82\ Hz \cong 80MHz$$

Dissipated Power:

$$P_{diss} = 2(\mathrm{V}_{cc}\mathrm{I}_{c1} + \mathrm{V}_{cc}\mathrm{I}_{c3}) = 2 * 3.3 * (4.23456 + 0.90335)$$
$$= 33.91\mathrm{mW}$$

Input resistance:

$$R_{in} = 2 * r_{\pi 1} = 1416.9\Omega$$

Output resistance:

$$R_{out} = R_3 = 250\Omega$$

Linearity range of the amplifier:

When $V_{ce2} > 0.2$ v

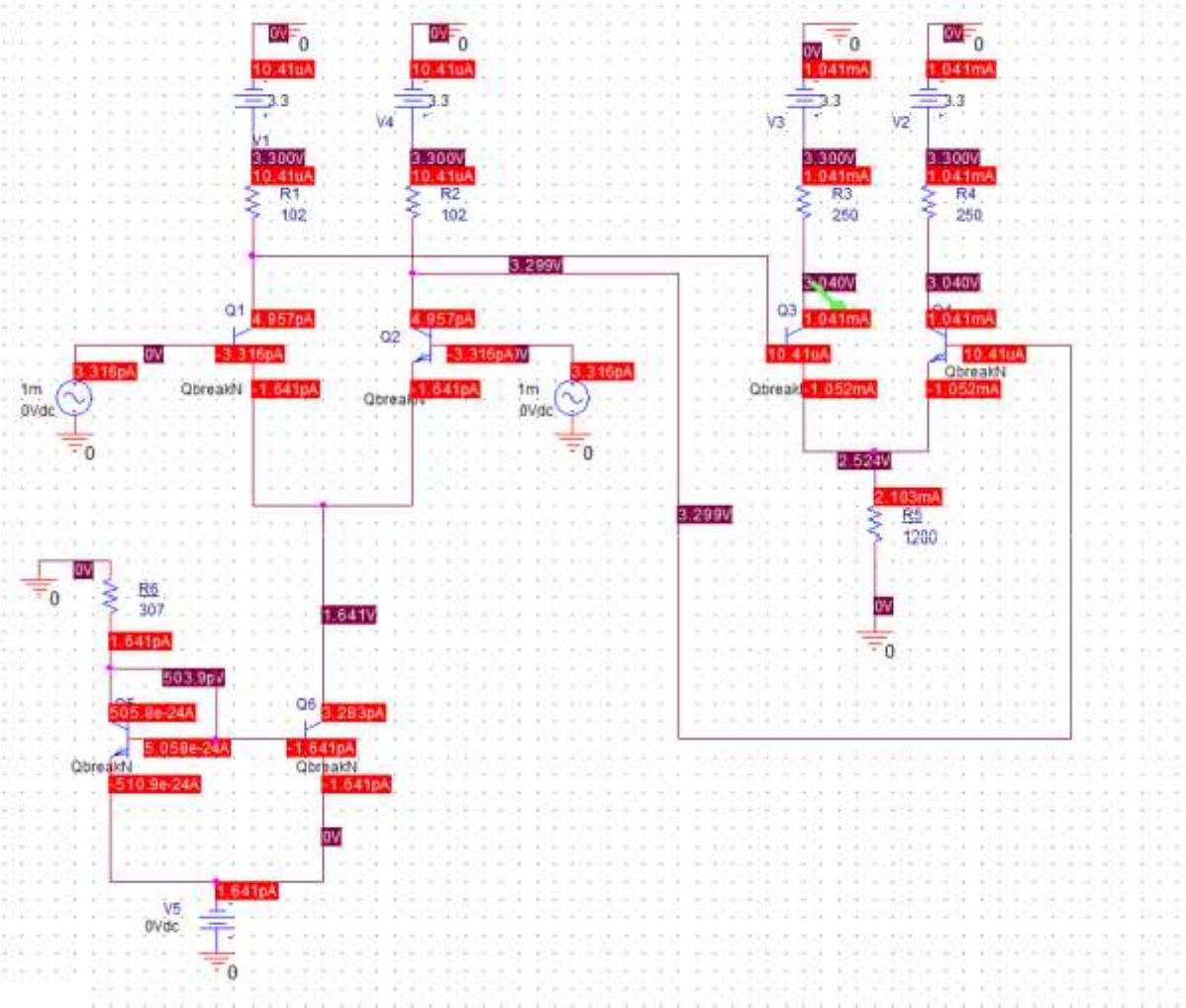
So it is from $V_{ce} = 0.2V$ to $V_{cc} = 3.3V$

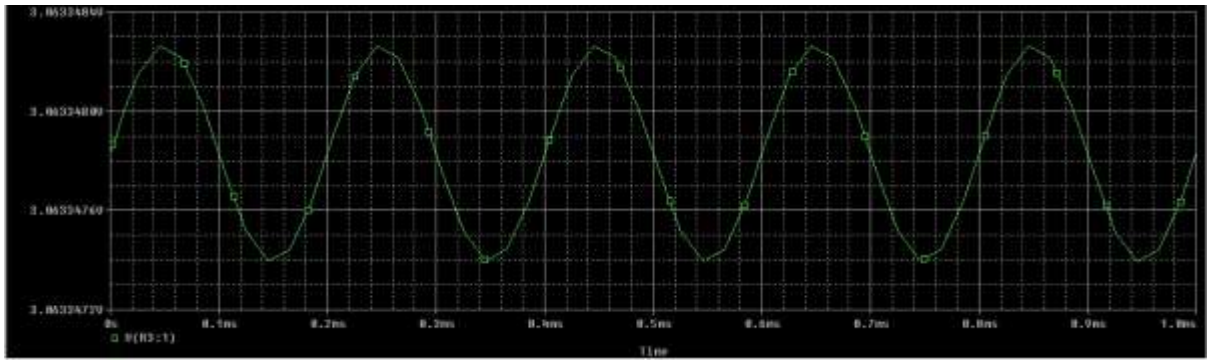
$V_{ce2} = V_{cc} - I_c(R_3 + 2R_5)$= 3.1 v

Input swing: $3\ mv$ peak to peak

Output swing: $0.2\ mv$ peak to peak

Simulation Results





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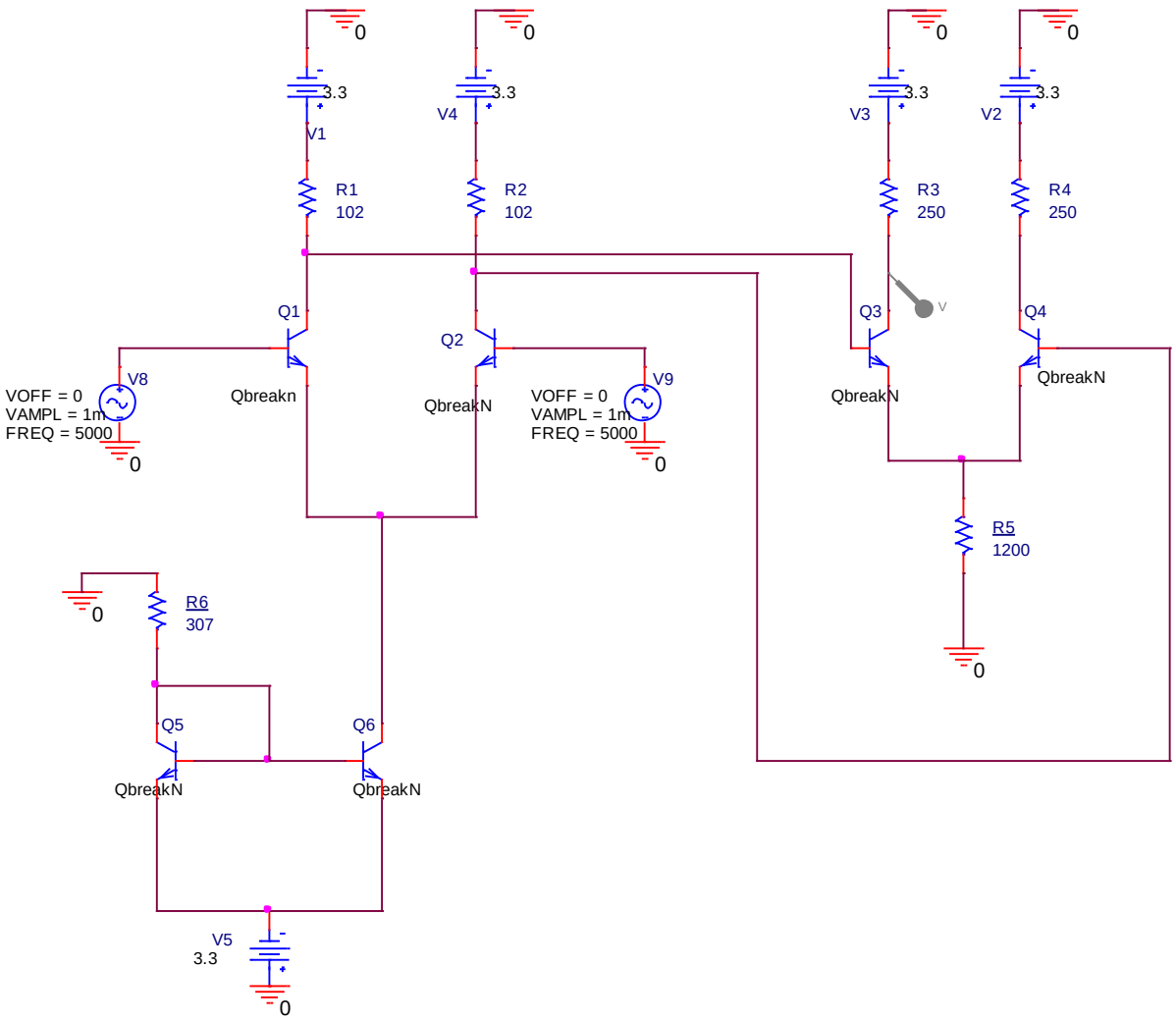
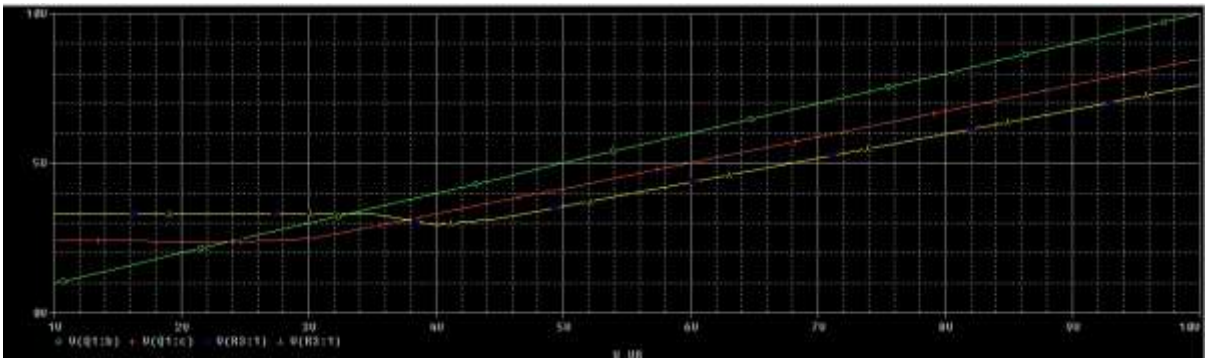
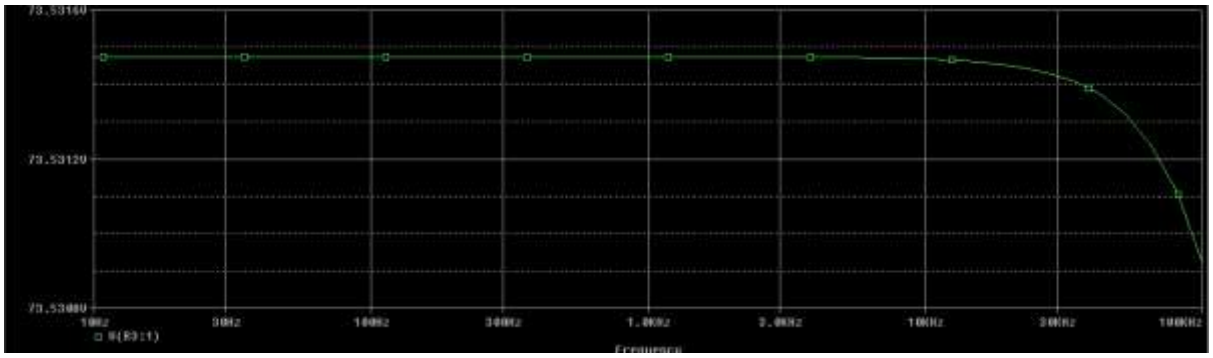
DC Sweep







Fe bardu ba2y rsomat hena .. el simulation el gamel msh 3arf azabato :D