LC oscillator Design

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1 Resonnator study

1.1 Evaluation of r_{L}

This Lab is dedicated to the design and the characterization of an LC cross-coupled oscillator in a 350nm CMOS Technology with Cadence Virtuoso. After having studied the resonator, the LC oscillator will be studied so that the performances of the whole oscillator could be deducted.

$$Q_{\mathrm{L}} = \frac{|jL\omega|}{r_{\mathrm{L}}} \tag{1}$$

$$r_{\mathrm{L}} = \frac{|jL\omega|}{Q_{\mathrm{L}}} \tag{2}$$

$r_{\mathrm{L}} = 1,36\Omega$

1.2 Determination of the value of C in order to have a frequency of 433MHz

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \tag{3}$$

$$C = \frac{1}{4\pi^2 L f_0^2} \tag{4}$$

C=13,5pF

1.3 Determination of the tank losses R_{L}

$$R_{\mathrm{L}} = Q_{\mathrm{L}}|jL\omega_0| \tag{5}$$

$R_{\mathrm{L}} = 544\Omega$

1.4 Simulation of the resonator

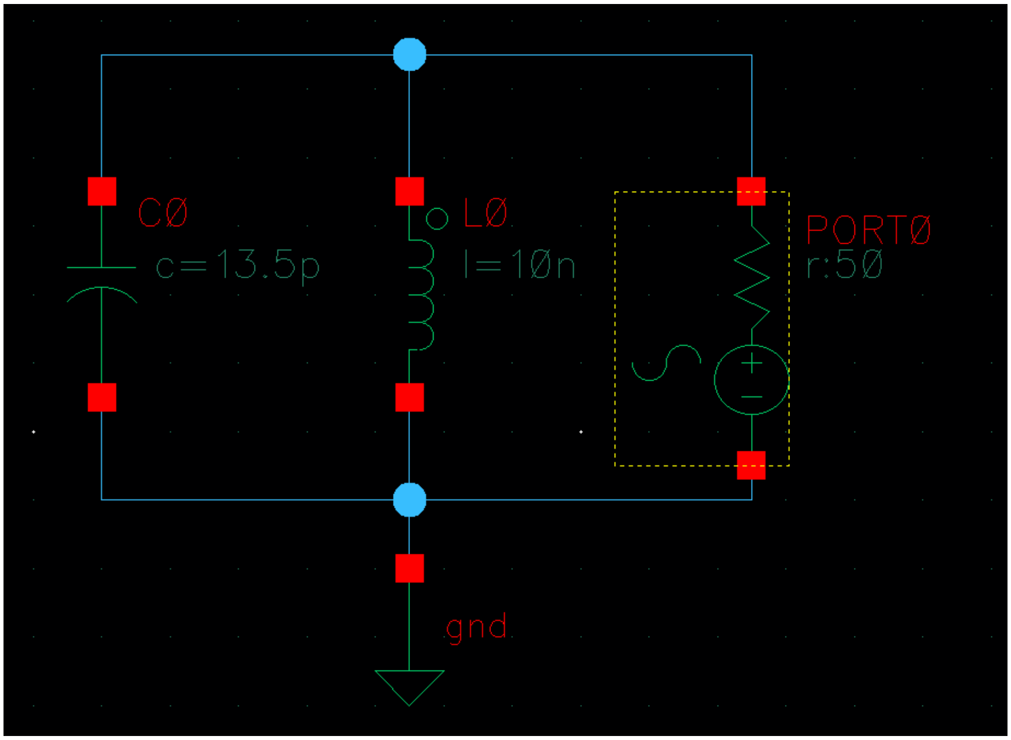

Figure 1: Schematic of the resonator

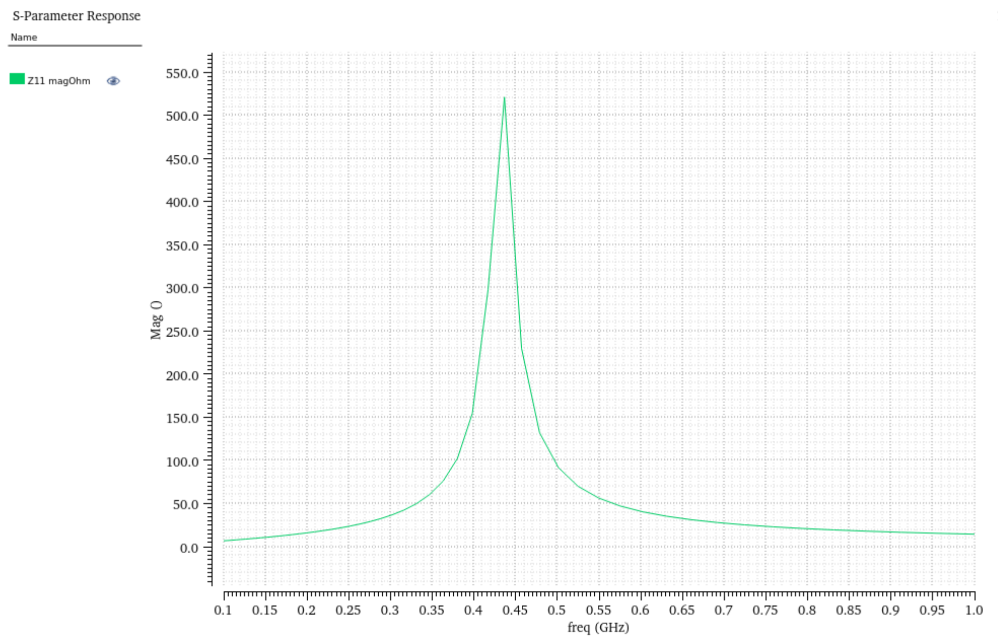

Figure 2: Simulation results of the resonator impedance

As shown in the simulation, the previously founded value of C is good because we have the pick at the frequency of 433MHz.

2 LC Oscillator study

2.1 Determination of the theorical transconsductance (g_{mstart})

For this circuit we alrealy calculated that :

$$R_T = \frac{-2}{g_{mstart}} \tag{6}$$

$$g_{mstart} = \frac{-2}{R_T} \tag{7}$$

g_{m1} is, en practice set to twice g_{mstart}
$|g_{mstart}| = 3,68mS$

2.2 Estimation of I_{bias}

$$g_{mstart} = \frac{I_{bias}}{V_{GS} - V_{TN}} \quad (8)$$

$$I_{bias} = (V_{GS} - V_{TN}) g_{m1} \tag{9}$$

if $(V_{GS} - V_{TN})$ is =300mV, then I_{bias} = 2,208mA.

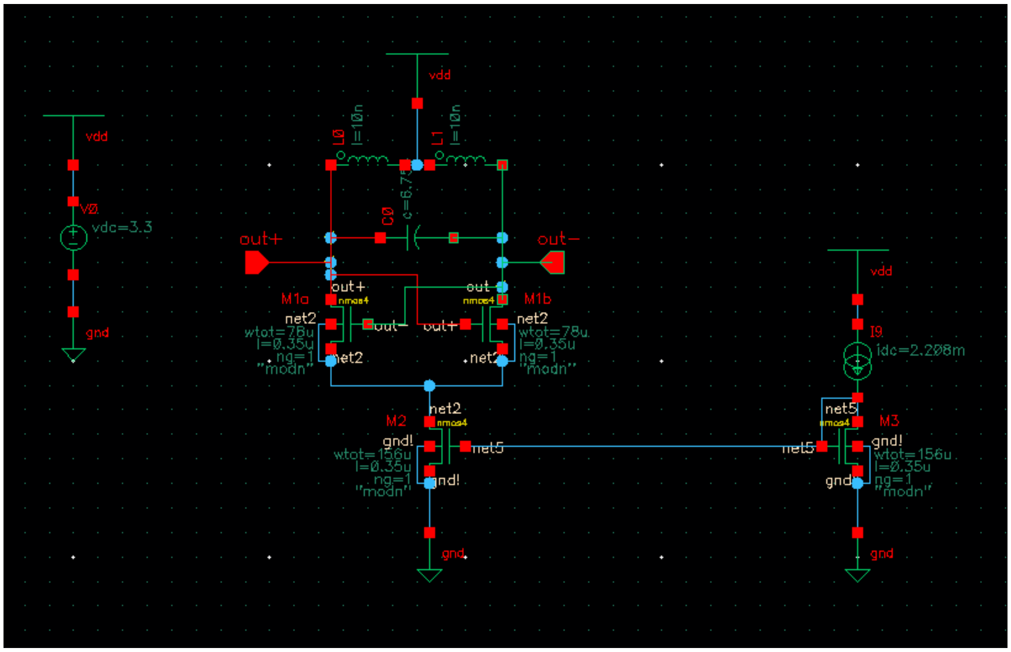

Figure 3: LC oscillator schematic

2.3 Estimation of geometrical parameters of the 3 transistors

$$w_1 = \frac{L_1 g_{\mathrm{m1}}}{2K_{\mathrm{n}}(V_{\mathrm{GS}} - V_{\mathrm{TN}})} = 78\mu m \tag{10}$$

$$w_2 = w_3 = \frac{L_2 g_{\mathrm{m2}}}{2K_{\mathrm{n}}(V_{\mathrm{GS}} - V_{\mathrm{TN}})} = 156\mu m \tag{11}$$

W1 is 2 times smaller than W2 and W3 because it has 2 times more current going through it.
Output plotting :

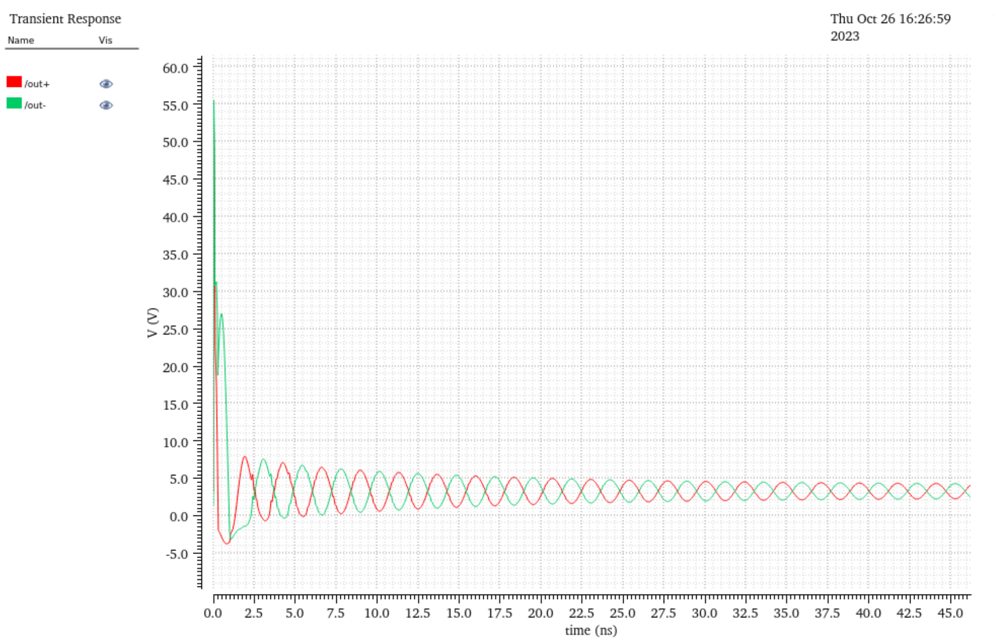

Figure 4: Time representation

pss analysis :

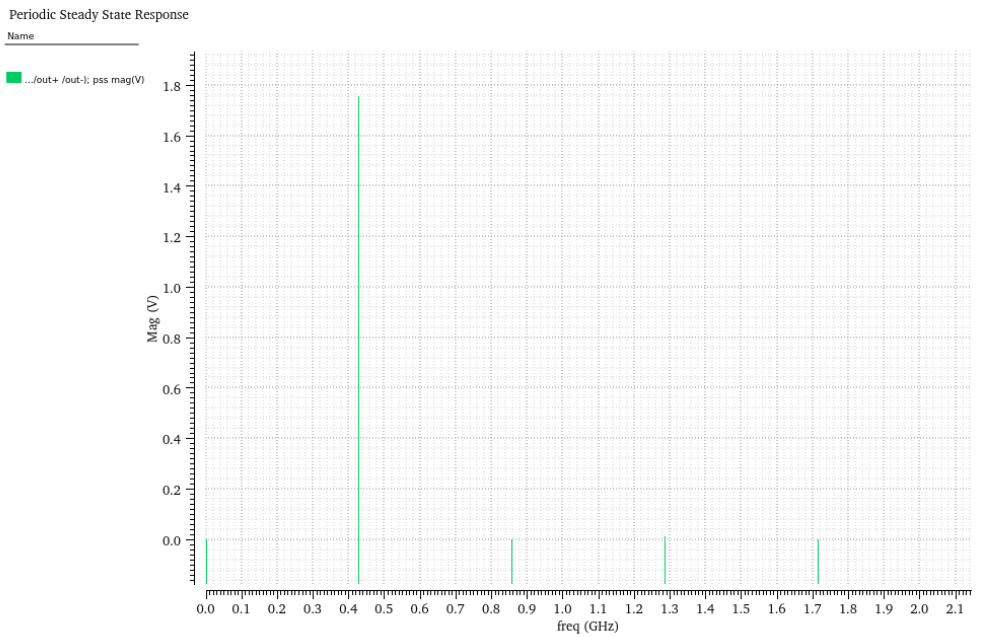

Figure 5: frequential representation

3 Oscillator performance

3.1 Estimation of the differential output

$$V_{\text{outdiff}} = 2\frac{4I_{\text{bias}}}{\pi 2}(Q_{\text{L}}\omega_{\text{osc}}L) \tag{12}$$

$V_{\text{outdiff}} = 1,524V$

3.2 Estimation of the Phase Noise (PN)

$\Delta\omega_{\text{osc}} = 100KHz$
$\omega_{\text{osc}} = 433MHz$

$$PN(\Delta\omega) = \frac{3kT}{V^2_{\text{outdiff}}(Q_{\text{l}}\omega_{\text{osc}}C_{\text{tanl}})}(\frac{\omega_{\text{osc}}}{\Delta\omega_{\text{osc}}})^2 \tag{13}$$

$PN(\Delta\omega) = 1,365 * 10^-13$
$PN(\Delta\omega) = -128dBc/Hz$

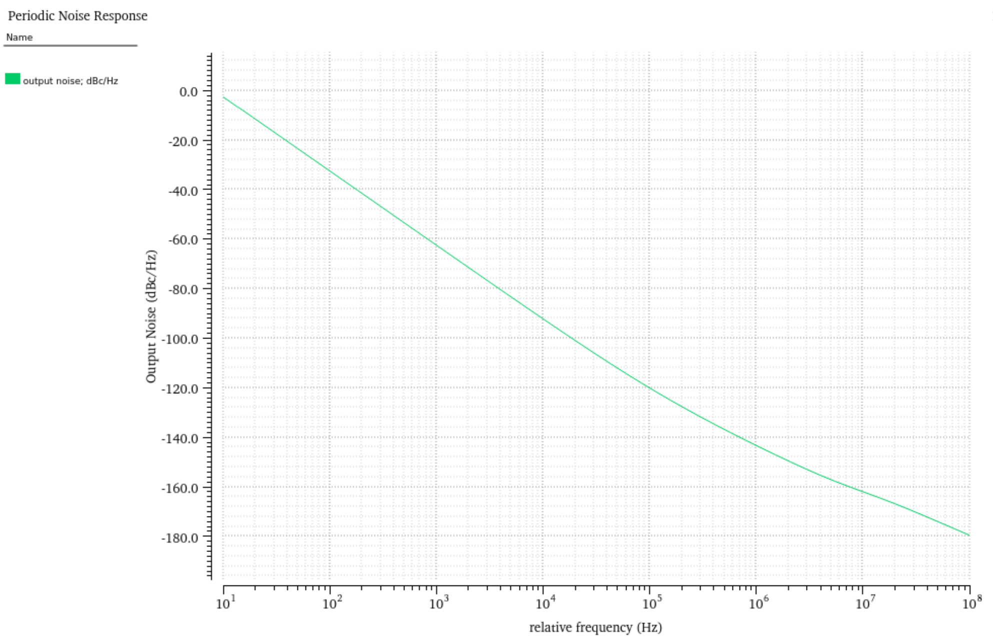

Figure 6: frequential representation

3.3 Theorical and simulation values comparison

@433MHz	Units	Specification	Theory	Simulations
VDD	V	3.3	3.3	3.3
$V_{outdiff}$	V	>1	1.524	1.75
PN @ 100KHz	dBc/Hz	< -110	-128	-120
I_{bias}	mA	-	2.2	2.2
L	mH	-	10	10
C	pF	-	13.5	13.5
R_T	Ohm	-	544	521.1

4 Conclusion

As shown in the previous table, the simulation values are slightly close to the theoretical ones. The modeling of the simulation components is efficient enough to match the theoretical values.