Exercise of Electronics for Communication Systems Prof. C. Abbate, G. Busatto - A.A. 2018/2019

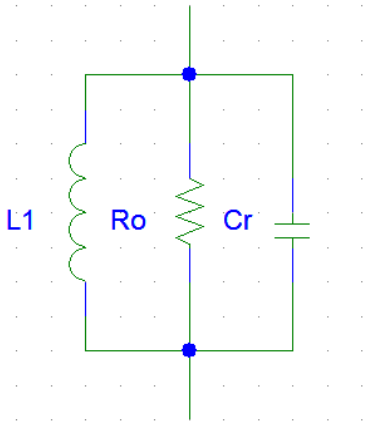
04 – Tuned amplifier with variable tuning frequency

29/10/2018 – Diego Tuzi – 50435 – diego.tuzi@studentmail.unicas.it

05/06/2020 (rev.1 exam 12/06/2020)

POINT A

With the help of the Schematics Capture tool of PSPICE, draw the schematic of the selective amplifier as in Fig. 1. The output filter is a transformer with a resonant input. The inductances of its primary and secondary are 100nH and 10nH, respectively. Compute the two values of Cr for which the resonance frequencies are: 98.7 MHz (=88+10,7MHz) and 118.7 MHz (=108+10,7MHz), which are minimum and maximum frequencies of the local oscillator, respectively. Resistance Ro is the load which, reported at the primary of the transformer, contributes to define the quality factor Q of the resonant circuit.



Equivalent output resonant circuit

An important property of this circuit is its ability to resonate at a specific frequency, the resonance frequency, f_0 .

$$\omega_0 = 2\pi f_0$$

Resonant circuit has the following resonant frequency

$$\omega_0 = \frac{1}{\sqrt{L_1 \cdot C_r}} \quad \text{with} \quad \omega_0 = 2\pi f_0$$

From previous formulas

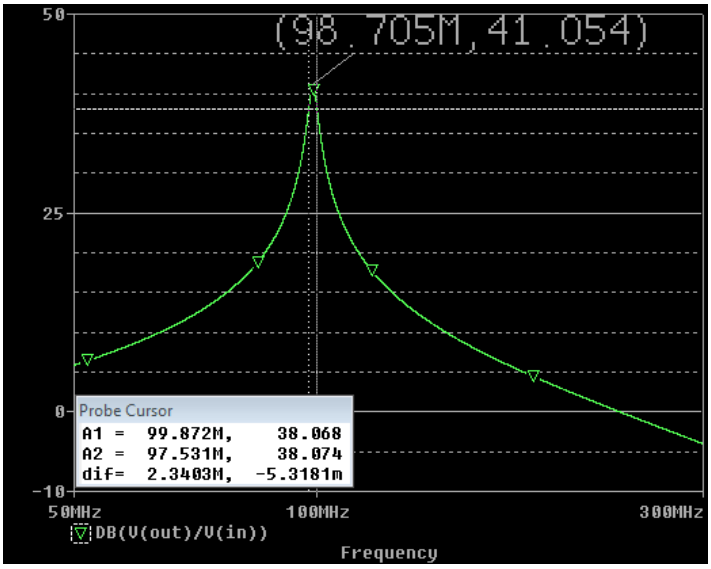
$$C_r = \frac{1}{L_1 (2\pi f_0)^2}$$

Therefore

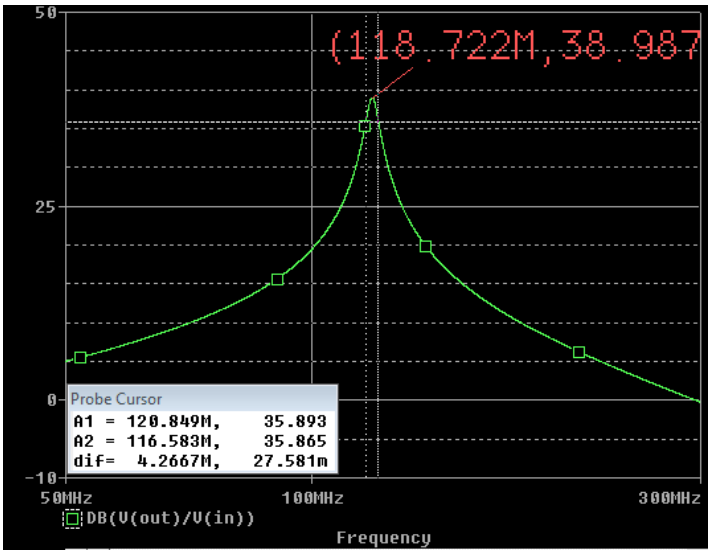
$$f_0 = 98{,}7\ MHz\ , C_r = 26\ pF$$
$$f_0 = 118{,}7\ MHz\ , C_r = 17{,}98\ pF$$

POINT B

Use the PSPICE AC analysis to verify that the amplifier is tuned at the two frequencies of interest. Determine the quality factor, Q, and the voltage gain, A, of the amplifier at the two extreme frequencies. Compare the results with the expected value of the gain (=g m ·r 0 //Ro').



To obtain f_o=98,7 → Cr=24,8 pF
Bandwidth=2,34 MHz
Voltage gain=41 dB
Q=42,18



To obtain f_o=118,7 → Cr=16,83 pF
Bandwidth=4,27 MHz
Voltage gain=39 dB
Q=27,78

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**** BIPOLAR JUNCTION TRANSISTORS

NAME	Q_Q1
MODEL	QBF199
IB	4.39E-05
IC	4.52E-03
VBE	7.71E-01
VBC	-6.67E+00
VCE	7.44E+00
BETADC	1.03E+02
GM	1.66E-01
RPI	5.87E+02
RX	1.47E+01
RO	2.85E+04
CBE	5.58E-11
CBC	4.17E-13
CJS	0.00E+00
BETAAC	9.72E+01
CBX/CBX2	6.78E-14
FT/FT2	4.69E+08

Theoretical voltage gain

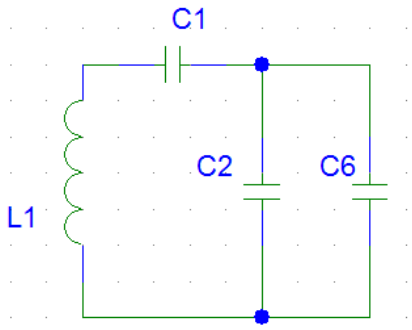
$$A = g_m (r_0 \,//\, R_0) = g_m \left(\frac{r_0 R_0}{r_0 + R_0} \right) \simeq 160{,}37$$

$$A_{db} = 20 \log_{10}(A) \simeq 44{,}1\ dB$$

Where g_m and r_0 are taken from output file of simulation

POINT C

We will use a varicap diode C6 to regulate the tuning frequency of the amplifier by means of Vcontr. The schematic of the circuit is reported in Fig. 2 which includes also the capacitors C1 and The varicap diode C6 is biased by Vcontr through R3 and is DC decoupled from the amplifier by the capacitor C3. It is worth to note that the resonance frequency of the output circuit is defined by the transformer inductance and the series between C1 and the parallel between C2 and the output capacitance of the varicap.
Capacitor C3 is chosen very high and can be neglected compared with the capacitance of the varicap. The CV characteristics of the varicap BB204 is supplied in Fig. 3. For 1V <=Vcontr<=10V the varicap capacitance varies from 52pF to 23pF. Compute C1 and C2 in order to achieve Fig. 2 Caratteristica C-V del varicap BB204 the minimum and maximum tuning frequencies of the output filter in correspondence of the extreme values of Vcontr. These frequencies will be the extreme oscillation frequencies of the VCO as it will be shown in the next exercise.



Equivalent output resonant circuit

Solving the equivalent system, you can obtain the following values.

$$C_1 = 49{,}67\ pF$$

$$C_2 = 2{,}57\ pF$$

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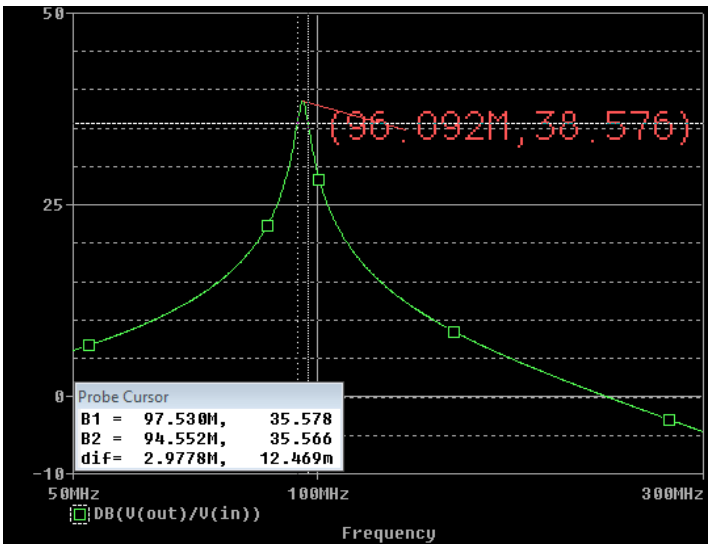
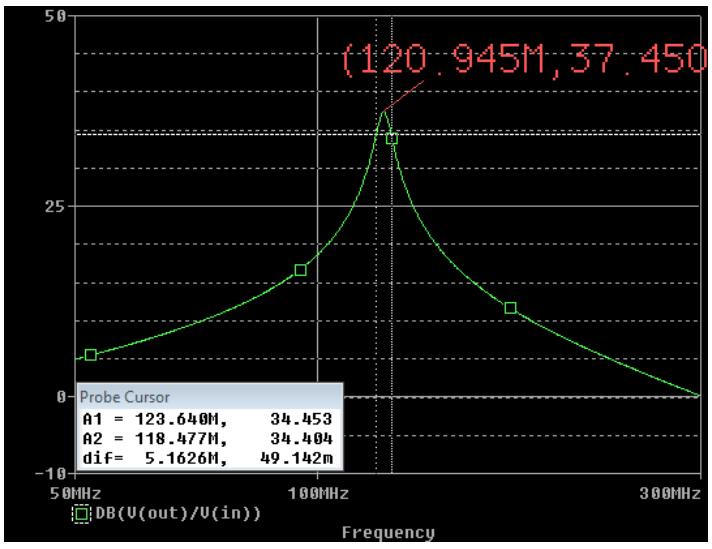
POINT D

Use a PSPICE AC analysis to verify that the amplifier is tuned at the minimum and maximum frequency of interest for VContr= 10V and VContr=1V, respectively. Determine the quality factor, Q, and the voltage gain, A, of the amplifier at these two frequencies.

	
Vcontr=1V Resonant frequency = 96.1MHz Voltage Gain=38,58 dB Bandwidth = 2,98 MHz Q=32,25	Vcontr=10V Resonant frequency = 120.9MHz Voltage Gain=37,45 dB Bandwidth = 5,16 MHz Q=23,43