02 – WIDE BAND CASCODE AMPLIFIER

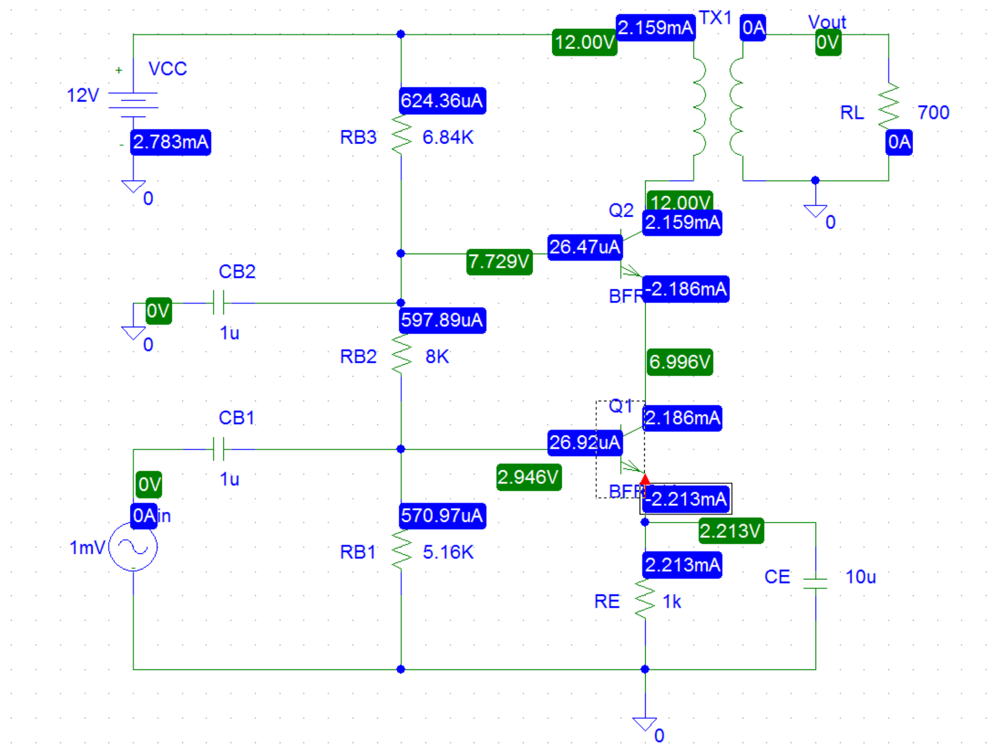
11/10/2018 – Diego Tuzi – 50435 – diego.tuzi@studentmail.unicas.it

03/06/2020 (rev.1 exam 12/06/2020)

Fig. 1 shows a wideband cascode amplifier with RL=700Ω and the coupling transformer having Lp=10mH, Ls=10mH and k=1. Compute RE, RB1, RB2 and RB3 in such a way to have:
IC1 ≈ IC2 ≈ 2.4 mA; VCE1 = VCE2 = 4.8V. Consider: VBE1 = VBE2 = 0.7 V; IB1 = IB2 ≈ 0A; RB1 + RB2 + RB3 = 20k.

$$V_{CC}-V_{CE2}-V_{CE1}-V_{E1}=0, \quad V_{E1}=V_{CC}-V_{CE2}-V_{CE1}=12V-4.8V-4.8V=2.4V$$
$$V_{E1}=R_E I_{C1}, \quad R_E=\frac{V_{E1}}{I_{C1}}=\frac{2.4V}{2.4mA}=1K\Omega$$
$$V_{B1}=V_{E1}+V_{BE1}=2.4V+0.7V=3.1V$$
$$V_{B1}=\frac{R_{B1}}{(R_{B1}+R_{B2}+R_{B3})}Vcc, \quad R_{B1}=\frac{(R_{B1}+R_{B2}+R_{B3})\cdot V_{B1}}{V_{CC}}=\frac{20K\Omega\cdot 3.1V}{12V}=5.16K\Omega$$
$$V_{E2}=V_{E1}+V_{CE1}=2.4V+4.8V=7.2V$$
$$V_{B2}=V_{E2}+V_{BE2}=7.2V+0.7V=7.9V$$
$$V_{B2}=\frac{(R_{B1}+R_{B2})}{(R_{B1}+R_{B2}+R_{B3})}Vcc, \quad R_{B2}=\frac{V_{B2}}{V_{CC}}(R_{B1}+R_{B2}+R_{B3})-R_{B1}=\frac{7.9V}{12V}\cdot 20K\Omega-5.16K\Omega=8K\Omega$$
$$R_{B3}=20K\Omega-5{,}17K\Omega-8K\Omega=6.84K\Omega$$

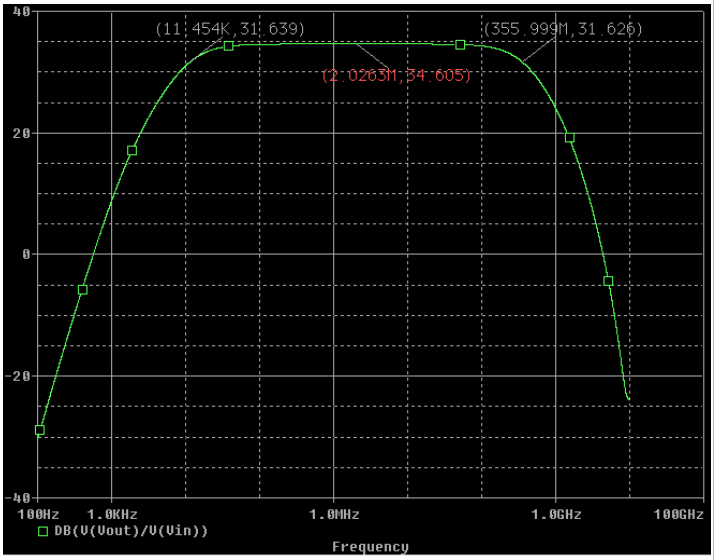
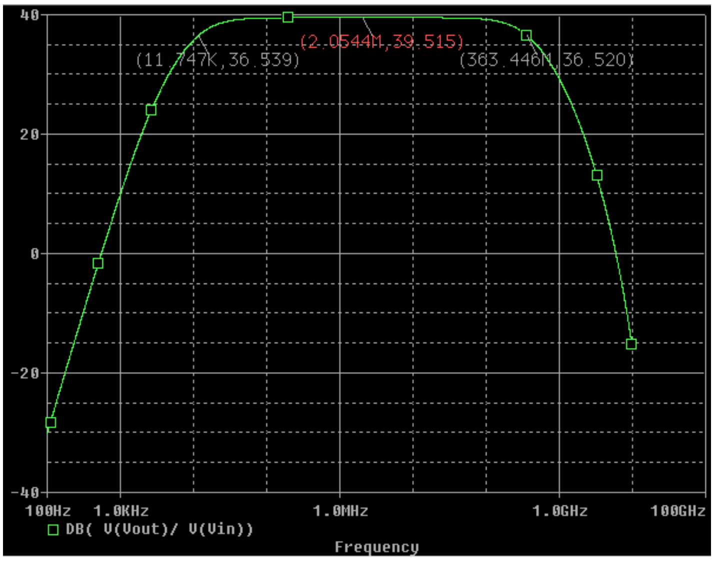
Draw the circuit using PSpice schematic. Insert the transistors "QbreakN" and edit the model using "Model, edit instance model (text)" in "Edit" drop down Fig. 1 - Wideband cascode amplifier menu. Copy and paste the BFR91A model parameters in the model window. Run the simulation and identify the DC bias point of Q1 and Q2. For this purpose activate "V" and "I" buttons in command bar of "PSpice Schematic" module. Verify that the bias point is close to what assigned in the previous step. Compute the expected voltage gain of the amplifier.



Simulated values are very close to expected.
The expected voltage gain could be approximated from the following equation:

$$A_V=-gm_{Q2}\cdot R_L=-57.82$$
$$A_{VdB}=20\log_{10}|A_V|=35.24\,dB$$

Activate "Setup analysis" menu from which select "AC sweep" and set the "start Freq" at 100Hz and the "stop Freq" at 10GHz with 1001 point/Dec. Moreover, select "Decade" option. Run the simulation and wait for the results to appear in "Probe" module. Add a trace with DB(V(Vout)/V(Vin+)) to visualize the harmonic response of the amplifier. Identify midband voltage gain, lower and upper 3dB cutoff frequencies. We suggest you to use "Toggle cursor" function for this task. Compare the midband voltage gain with the one computed in the previous step.

<table>
<tr><th>$R_E = 1\,K\Omega$</th><th>$R_E = 500\,\Omega$</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Mid band voltage gain = 34.6 dB (Max gain at 2,02MHz)
Low 3dB cut-off frequency = 11.45KHz
High 3dB cut-off frequency = 356 MHz

Experimental value of mid band voltage gain is very close to expected once.</td><td>Mid band voltage gain = 39.5 dB (Max gain at 2,05MHz)
Low 3dB cut-off frequency = 11.75KHz
High 3dB cut-off frequency = 363.44 MHz

As expected, reducing resistance RE changes the operating point.</td></tr>
</table>

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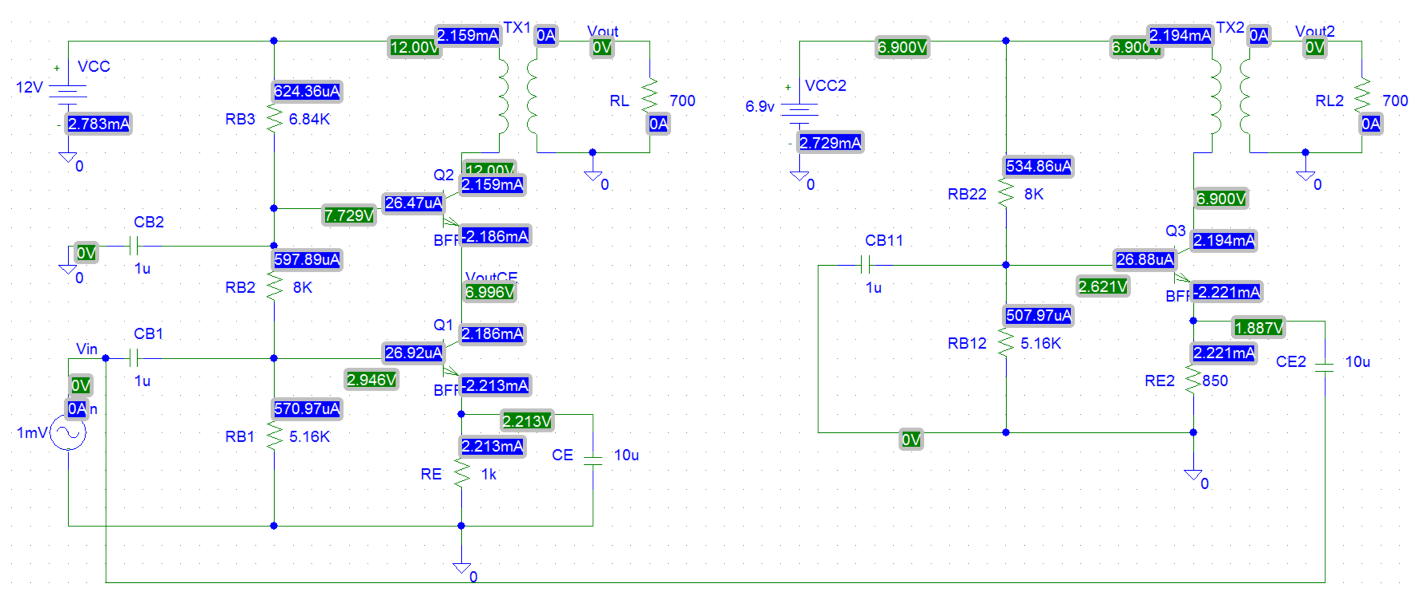
Draw a common emitter amplifier besides the cascode as it is done in Fig. 2. Connect its input terminal to the same input signal generator Vin. Verify that DC biasing points of Q1 and Q3 are reasonably coinciding.

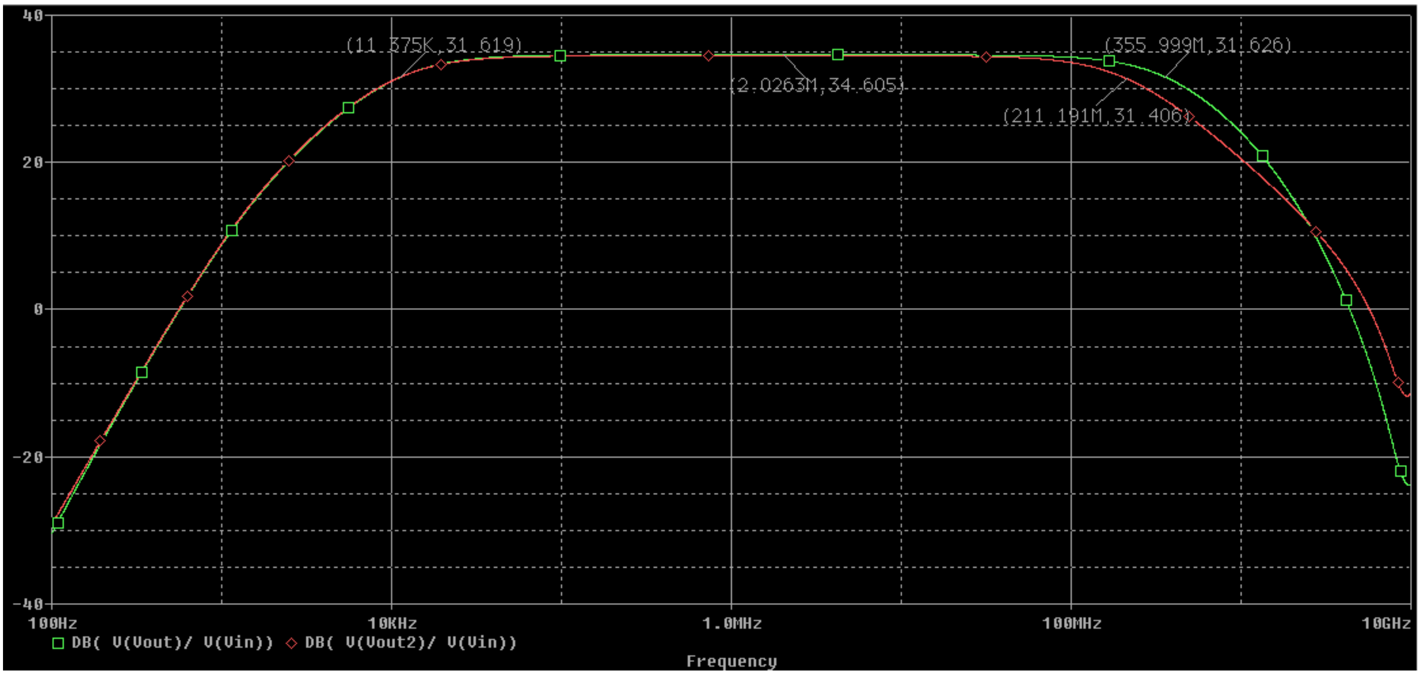
Cascode Amplifier	Common emitter amplifier



Biasing point of Q1 and Q3 are very close each other.

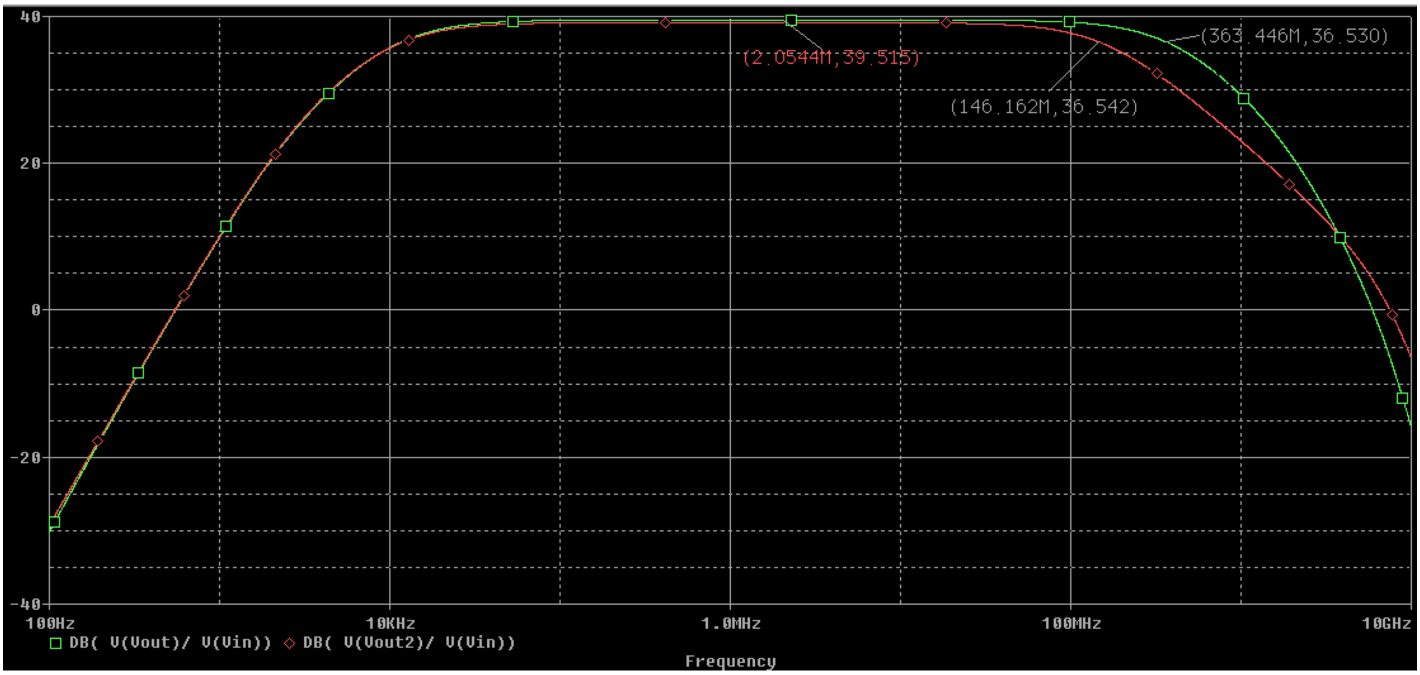
As it was done in point 2) plot the harmonic response of two amplifiers in the same plot.
Identify and compare midband voltage gains, lower and upper 3dB cutoff frequencies of the two amplifiers.

$$R_E = 1\,K\Omega$$



CASCODE and CEA have same mid-band gain (34.6 dB) and same low 3dB cut off frequencies (11.37 KHz).
High 3dB frequency of CEA = 211,2 MHz is lower than high 3dB frequency of CASCODE = 356 MHz, as you expect from theory.

$R_E = 500\,\Omega$



CASCODE and CEA have same mid-band gain (39.5 dB) and same low 3dB cut off frequency (11.75KHz).
High 3dB frequency of CEA = 146.1 MHz is lower than high 3dB frequency of CASCODE = 363 MHz, as you expect from theory.