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

Simulation of class AB RF Power amplifier

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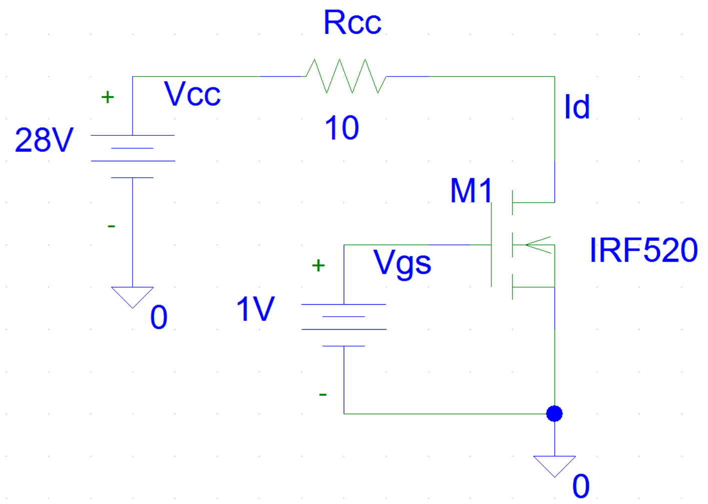
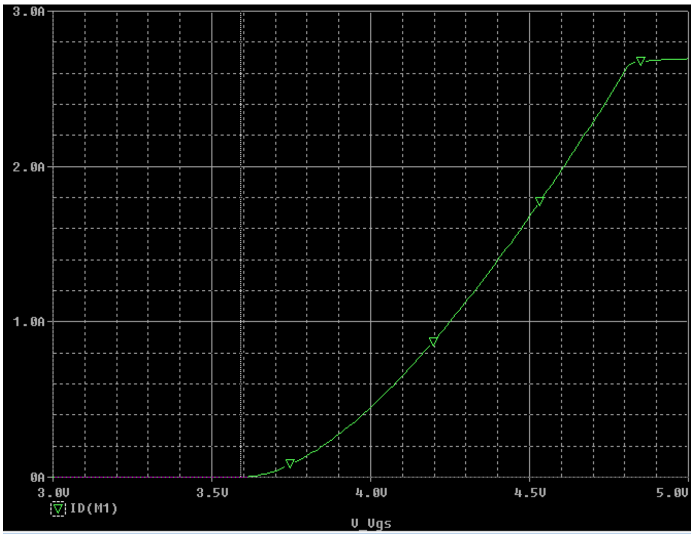
In this exercise, we analyze the operation of a class AB RF power amplifier RF. The power MOSFET IRF520A is used as active device. In particular, we want to realize an amplifier at 10MHz with an output power Po = 20W and standard in / out impedances of 50Ω. The supply voltage is set to 28V.



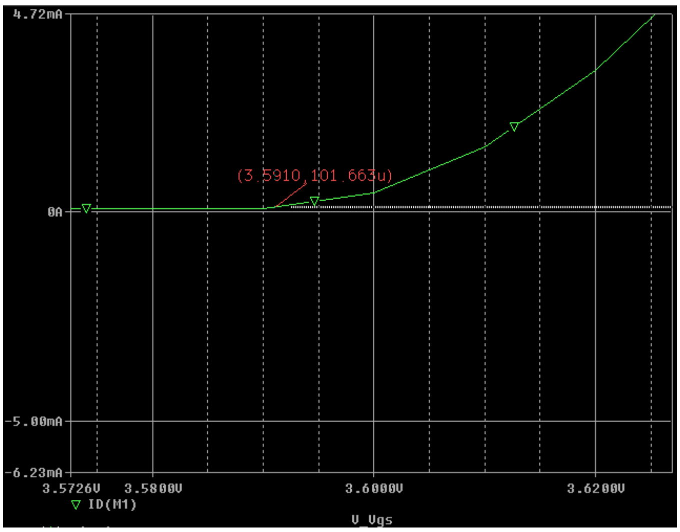
POINT 1 – The transfer static characteristic

In order to determine the transfer characteristic of the active device, draw the circuit shown in Fig. 1. Insert a MbreakN3 from the library of the simulator using the parameters available on Google Classroom website for the MOSFET IRF520A.

Perform a static analysis by varying the gate-source voltage between 3V and 5V with 0.01V step. Draw the drain current as a function of the voltage Vgs. Measure the device threshold voltage. (identify the voltage when the drain current is 100uA)



transfer characteristic of the active device



Id=100uA when Vgs=3,59V

POINT 2 – The measurement of input and output MOSFET impedances

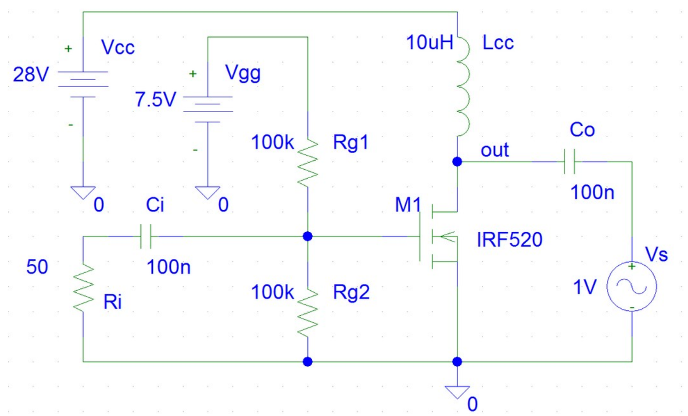
The common source class AB amplifier to be studied is shown in Fig. 2. A blocking inductance is inserted on the drain. The gate bias is realized by the battery Vgg and the voltage divider Rg1 and Rg2. Set the voltage their values in order to have a quiescent current Id0 of 80mA (use the results of the previous step).

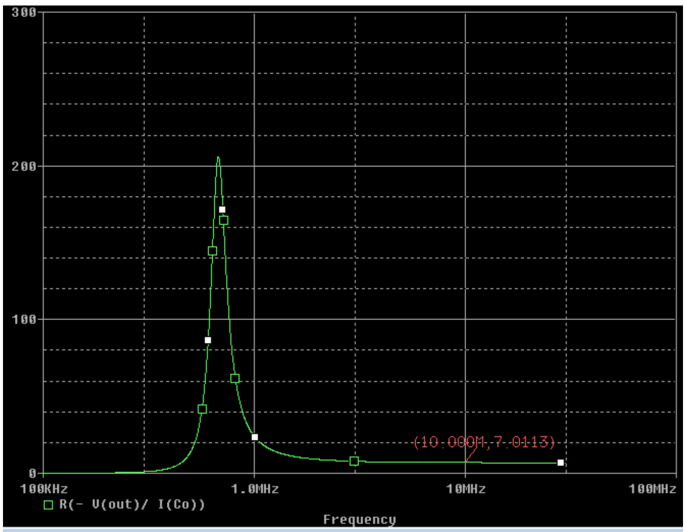
From transfer characteristic $I_D = 80\,mA$ when $V_{GS} = 3{,}75\,V$

$$V_{GS} = \frac{R_{G2} V_{GG}}{R_{G1} + R_{G2}} \quad \rightarrow \quad V_{GG} = \frac{(R_{G1} + R_{G2}) V_{GS}}{R_{G2}} = 2 V_{GS} = 7{,}5\,V$$

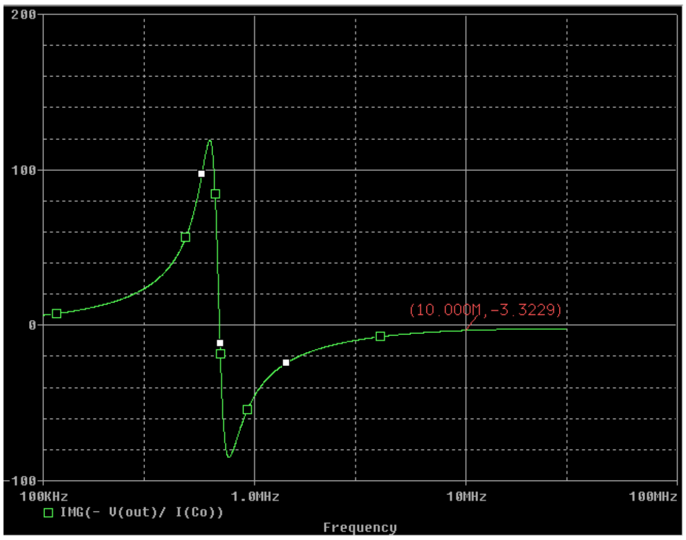
POINT 2A

Close the input port on a 50Ω. Use an AC analysis (Vs = 1V - large signal) to evaluate the real and imaginary parts of the output impedance of the active device at the frequency of interest.



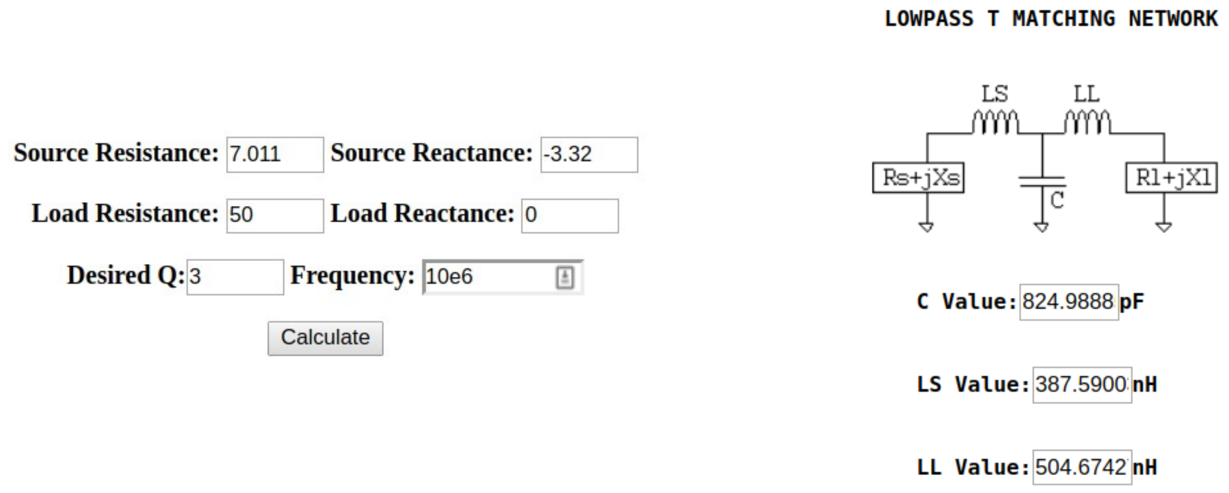


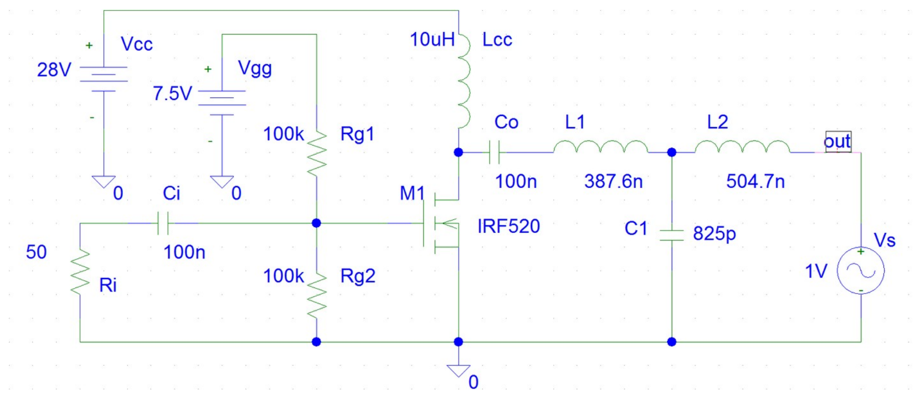
Real part of output impedance at 10MHz = 7,0113

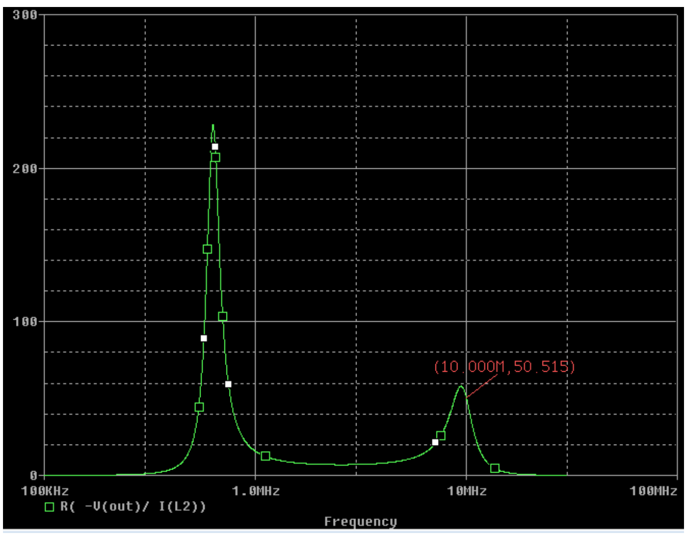


Imaginary part of output impedance at 10MHz = -3,3229

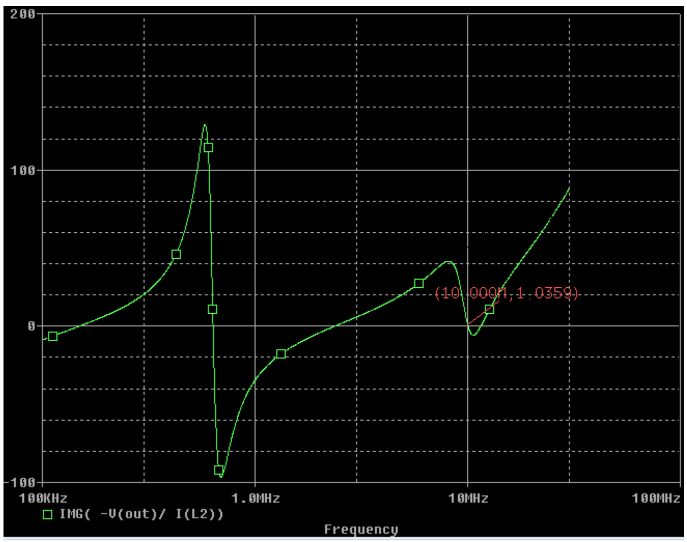
With obtained values, realize a 3 elements output matching network in order to adapt for maximum power transfer.







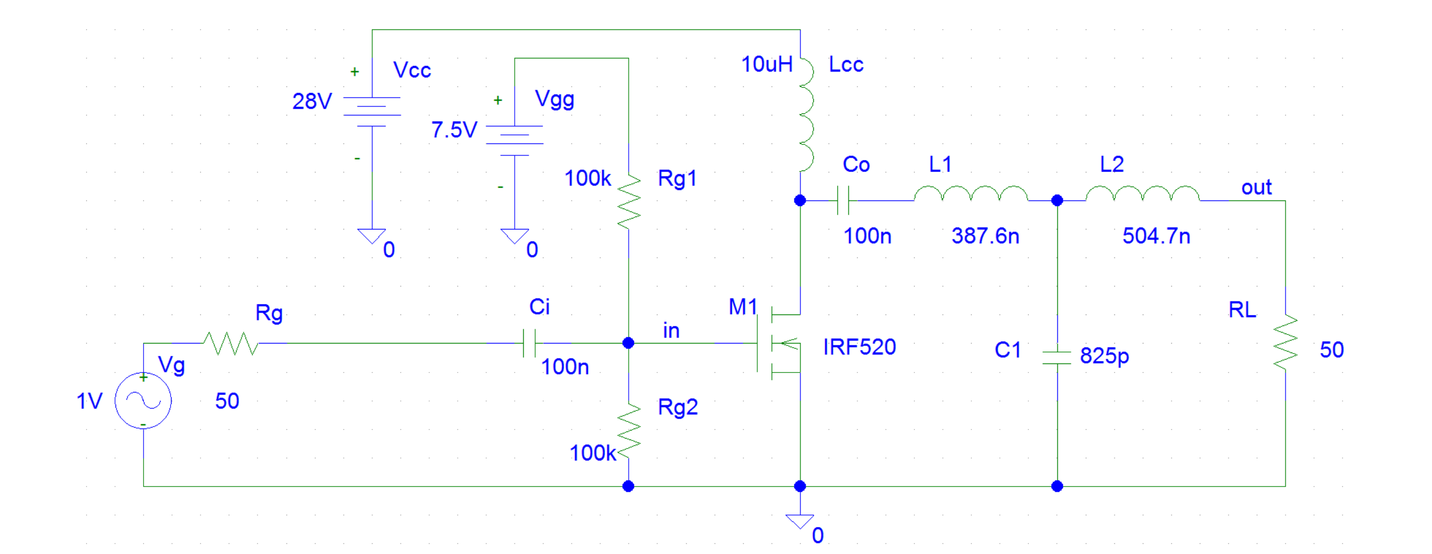
Real part of output impedance at 10MHz = 50,515 ohm

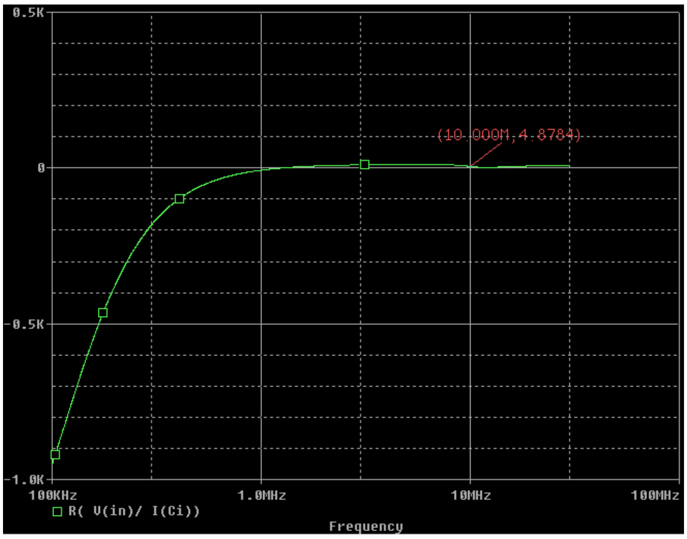


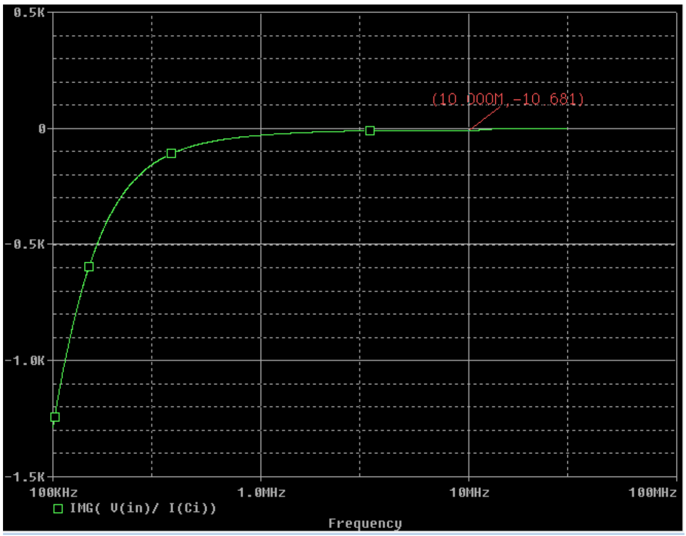
Imaginary part of output impedance at 10MHz = 1

POINT 2B

Only after having connected the output matching network, measure the input impedance of the amplifier.

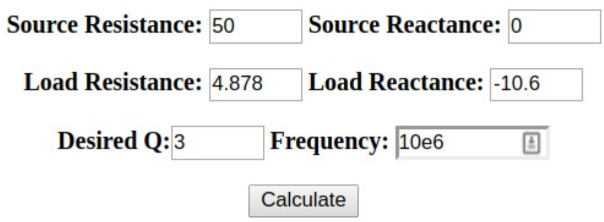


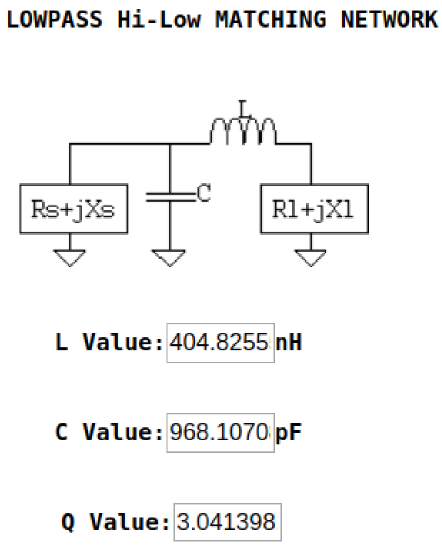


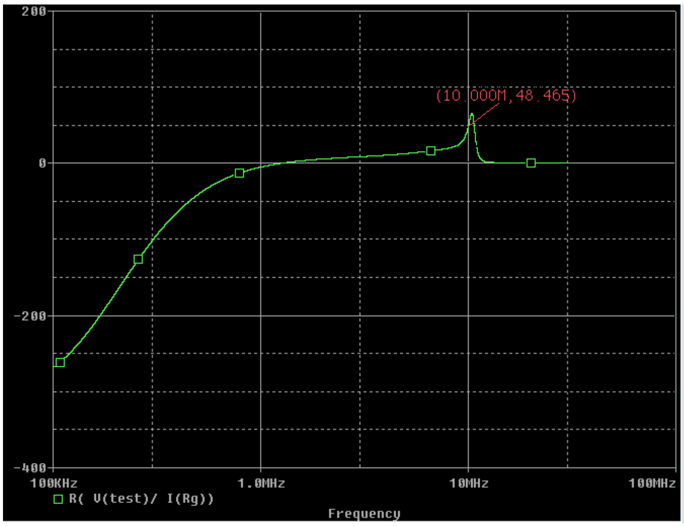


Real part of input impedance at 10MHz = 4,8784 ohm	Imaginary part of output impedance at 10MHz = -10,681

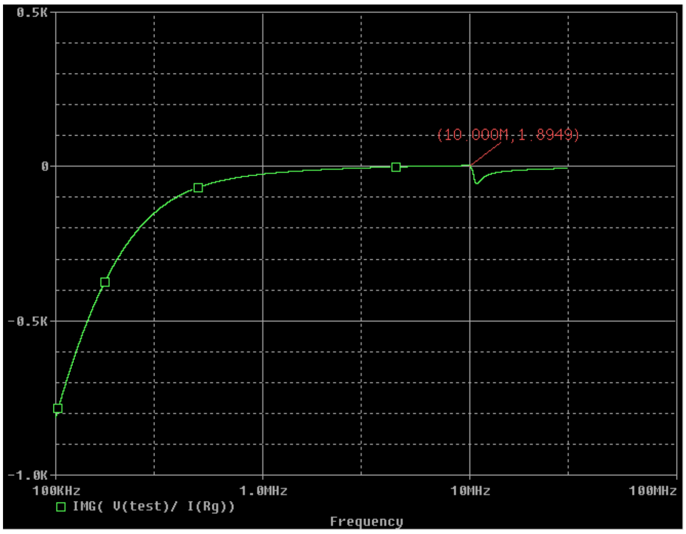
Design the corresponding 2-elements matching network.







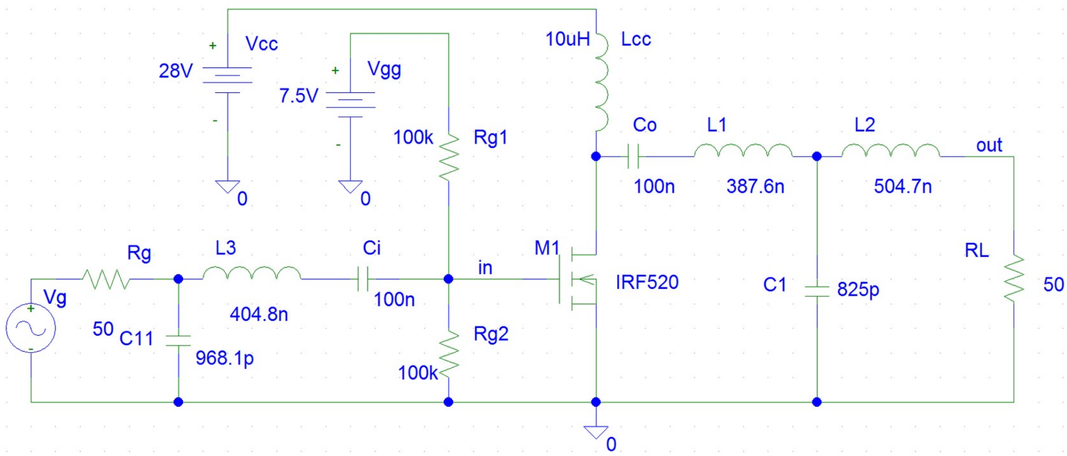
Real part of input impedance at 10MHz = 48 ohm

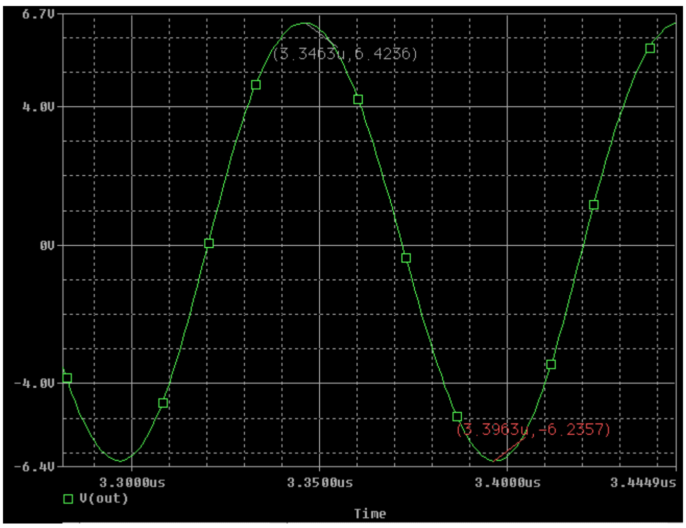


Imaginary part of output impedance at 10MHz = 1

POINT 3 – The verification of Amplifier Performances

Using the designed circuit, set an input sinusoidal signal Vg with amplitude of 1V and frequency 10MHz. Calculate the power gain by measuring output and input power. In order to measure the output power, measure the amplitude Vpp at output and calculate the power supplied to the load according to the relation Po = V PP2 / 8RL.





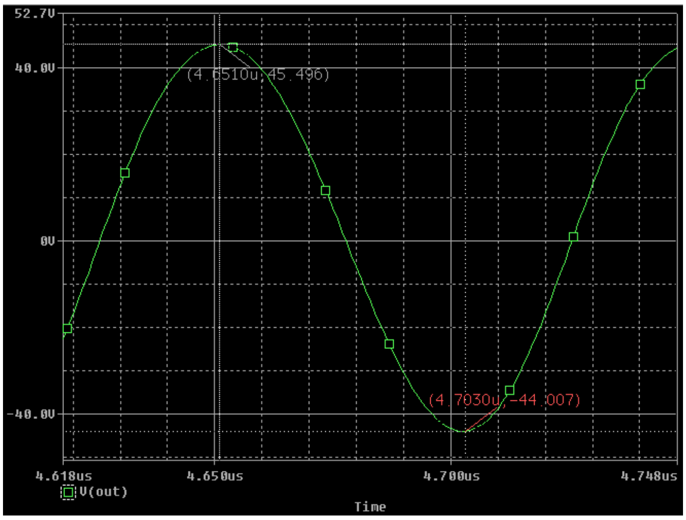
$$P_O = \frac{V_{PP}^2}{8 R_L}$$

$$R_L = 50\,\Omega$$

from simulation $V_{PP} = 12{,}66\,V$ with $V_G = 1\,V$

$$P_O \simeq 0{,}4\,W$$

Increase the amplitude of the input signal to obtain an output power of about 20W.



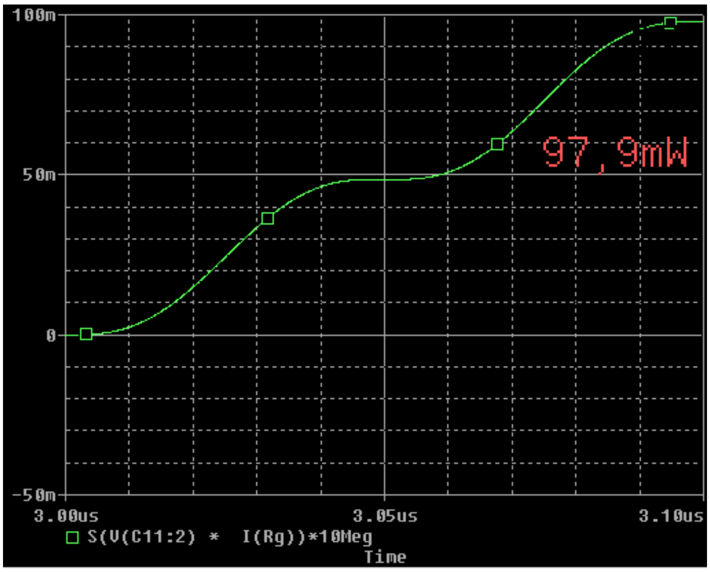
$$P_O=\frac{V_{PP}^2}{8\,R_L}$$

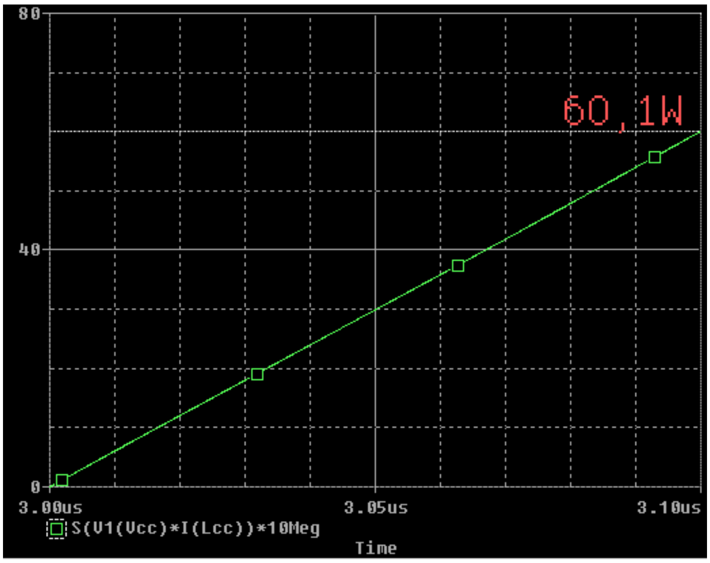
$$R_L=50\,\Omega$$

from simulation $V_{PP}=89{,}5\,V$ with $V_G=6{,}3\,V$

$$P_O\simeq 20{,}02\,W$$

*To calculate the input power supplied to the amplifier, evaluate the integral of the product VC11 * IRG in one signal period (Pspice expression, S (VC11 * IRG) * 10Meg). In a similar way, evaluate the power supplied by power supply Vcc and calculate the efficiency of the amplifier at nominal power.*





$$\eta=\frac{P_{OUT}}{P_{DD}}=\frac{20{,}02}{60{,}07}\,W\simeq 33{,}3\,\%$$

$$P_{\mathrm{IN}}+P_{DD}=P_{OUT}+P_{DISS}\quad\rightarrow\quad P_{DISS}=P_{\mathrm{IN}}+P_{DD}-P_{OUT}=0{,}097\,W+60{,}07\,W-20{,}02\,W\simeq 40{,}15\,W$$