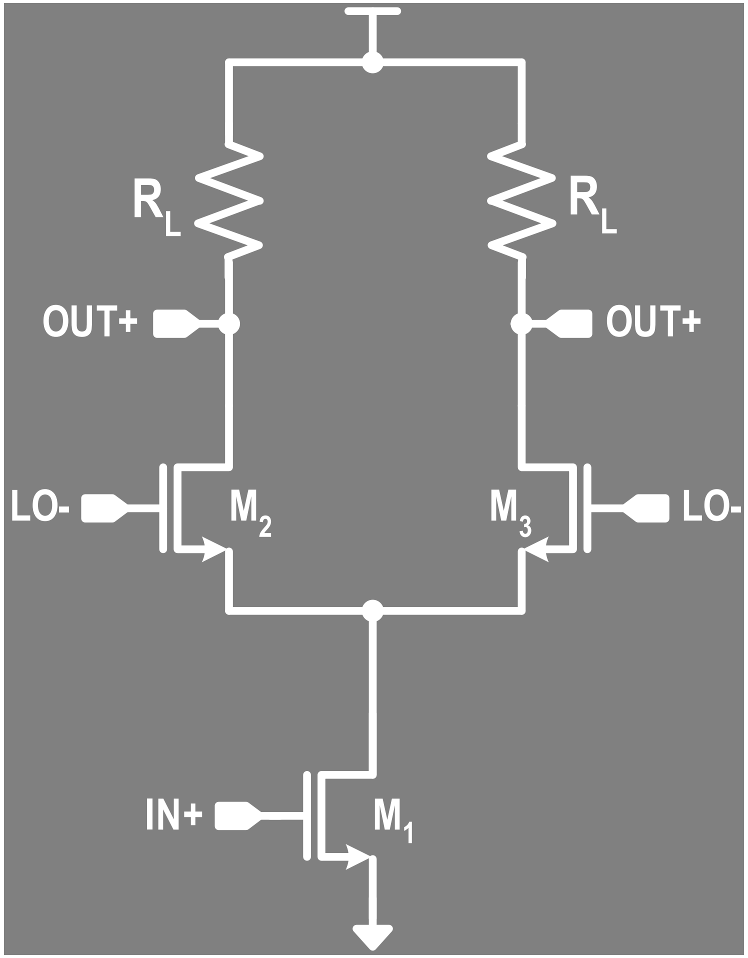
Gilbert Cell Mixer

University of Pavia

http://www.unipv.it/aic/

Gilbert Cell Active Mixer

"single - balanced" version



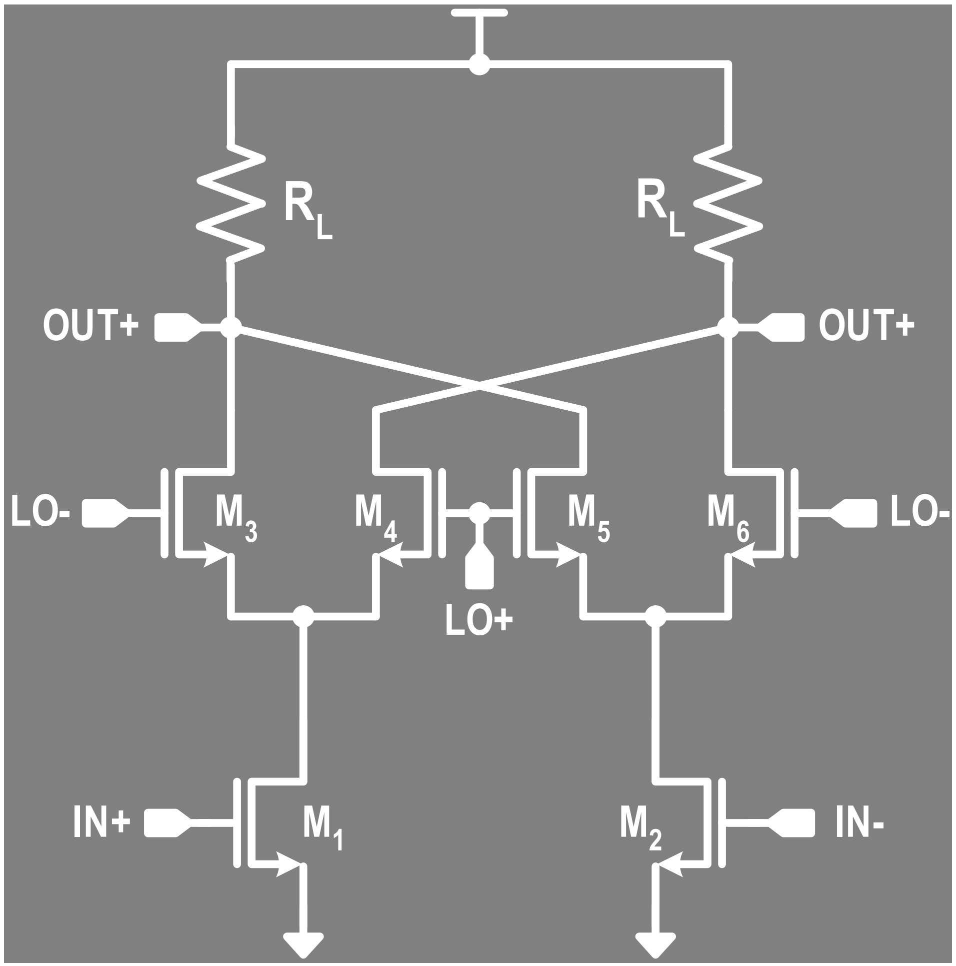
$$i_{RF} = g_{m1} V_{IN}$$ Drain current of M1

$$\frac{i_{OUT}}{V_{IN}} = g_{m1} \frac{2}{\pi}$$ Transconductance gain

$$\frac{V_{OUT}}{V_{IN}} = g_{m1} \frac{2}{\pi} R_L$$ Voltage Gain

Gilbert Cell Active Mixer

“double - balanced” version



$$i_{RF,M1} = g_{m1}\frac{V_{IN}}{2}$$

Drain Current of M1

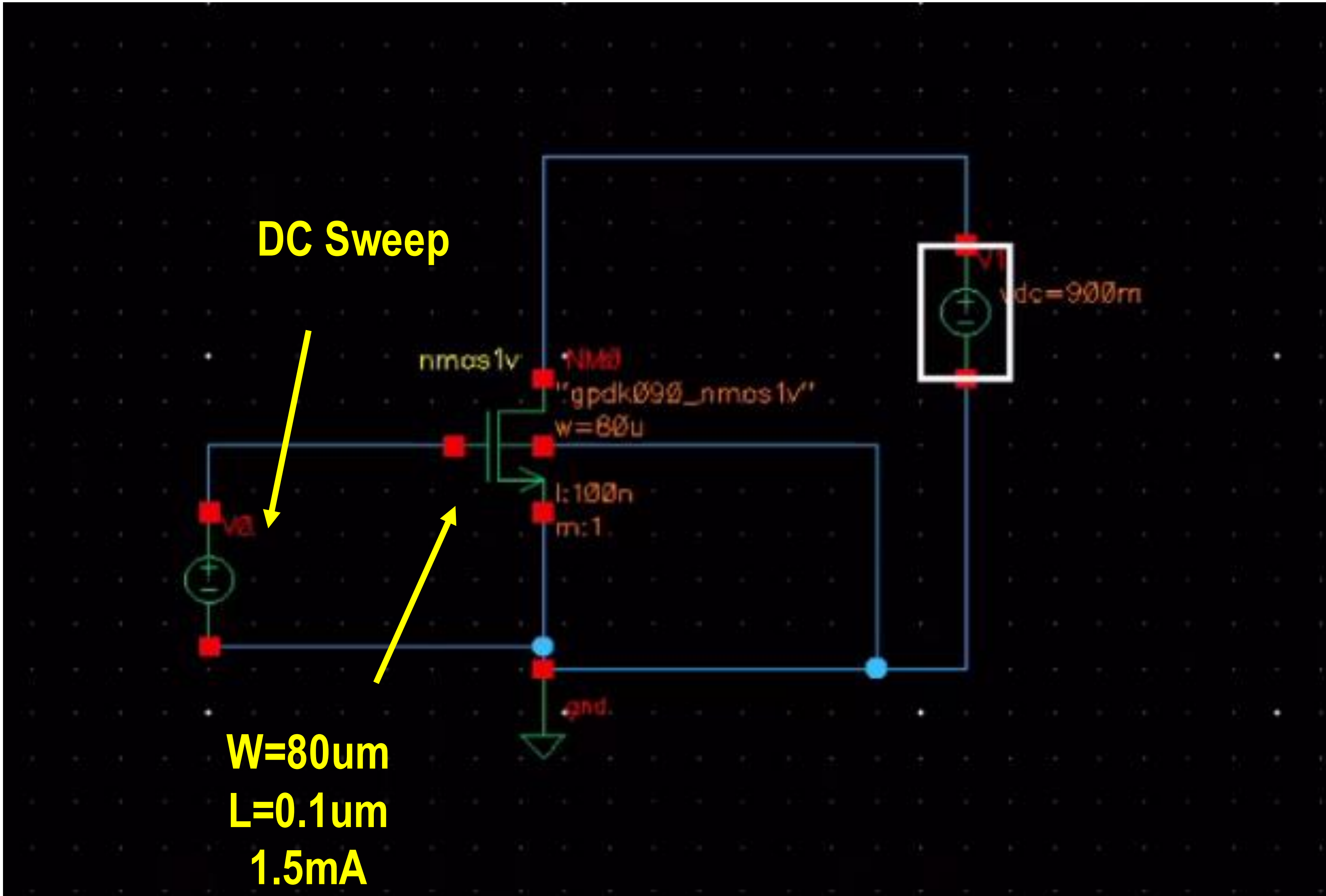
$$i_{RF,M2} = -g_{m2}\frac{V_{IN}}{2}$$

Drain Current of M2

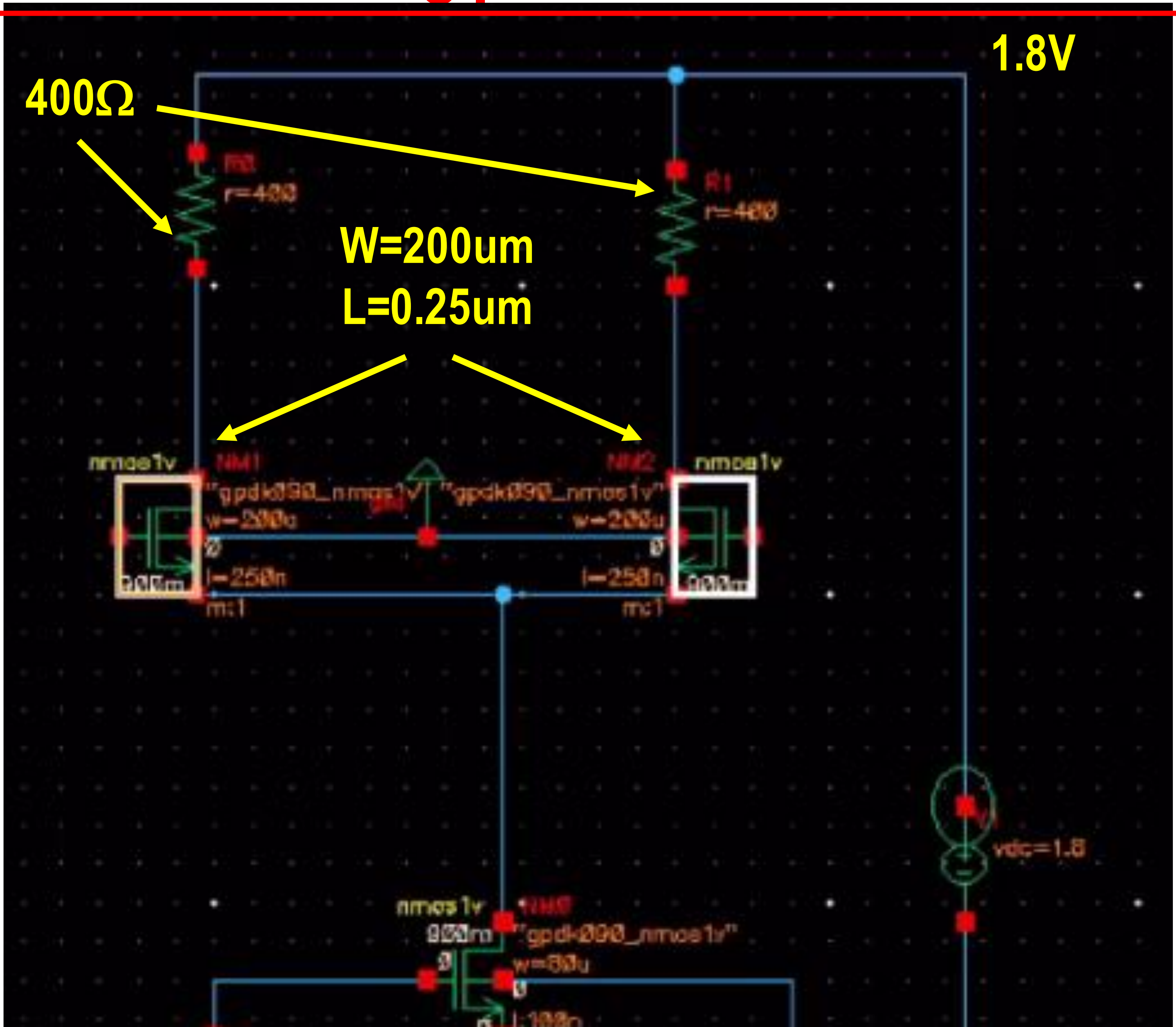
$$\frac{V_{OUT}}{V_{IN}} = g_{m1}\frac{2}{\pi}R_L$$

Voltage Gain

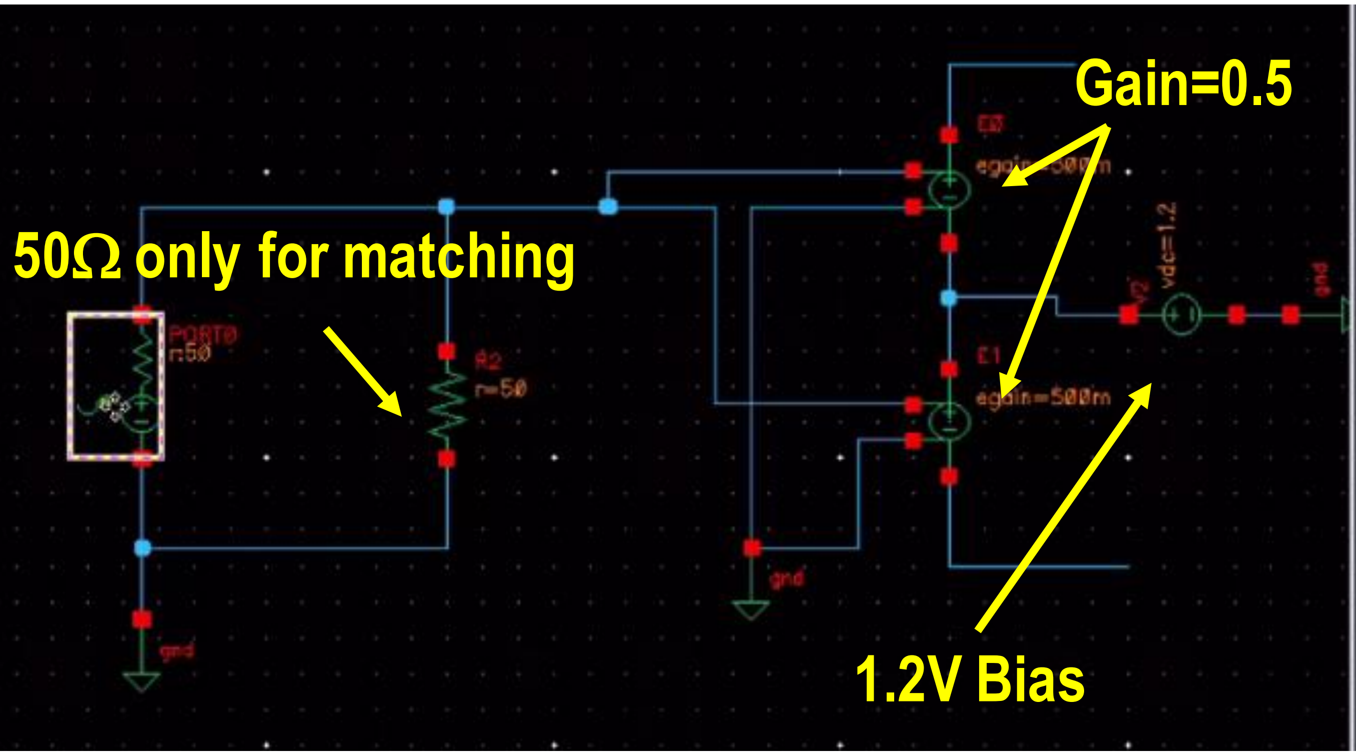
Transconductor Bias

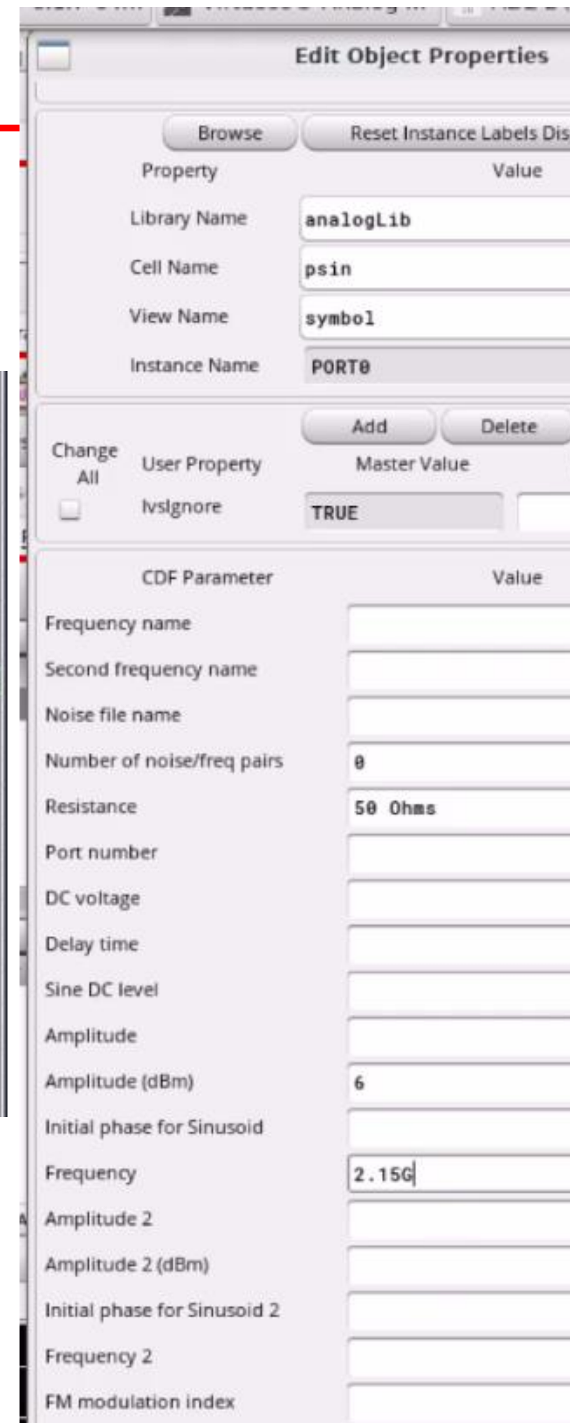


Switching pair and load

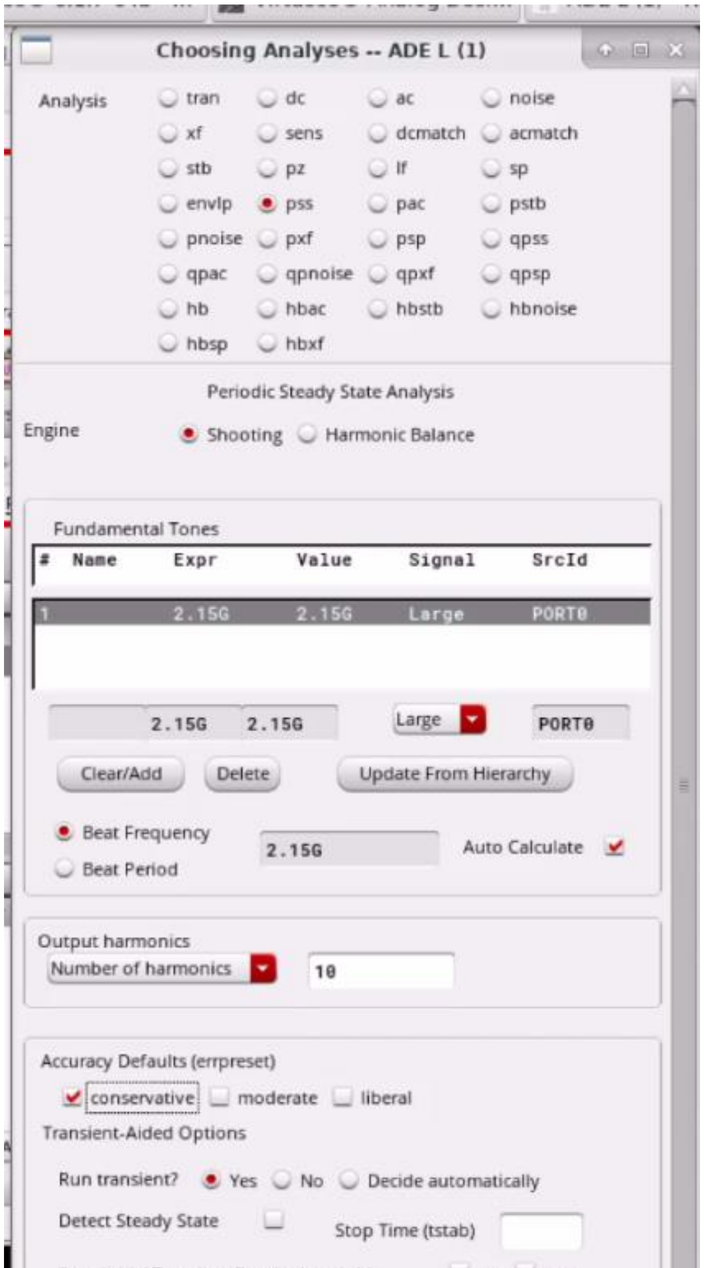


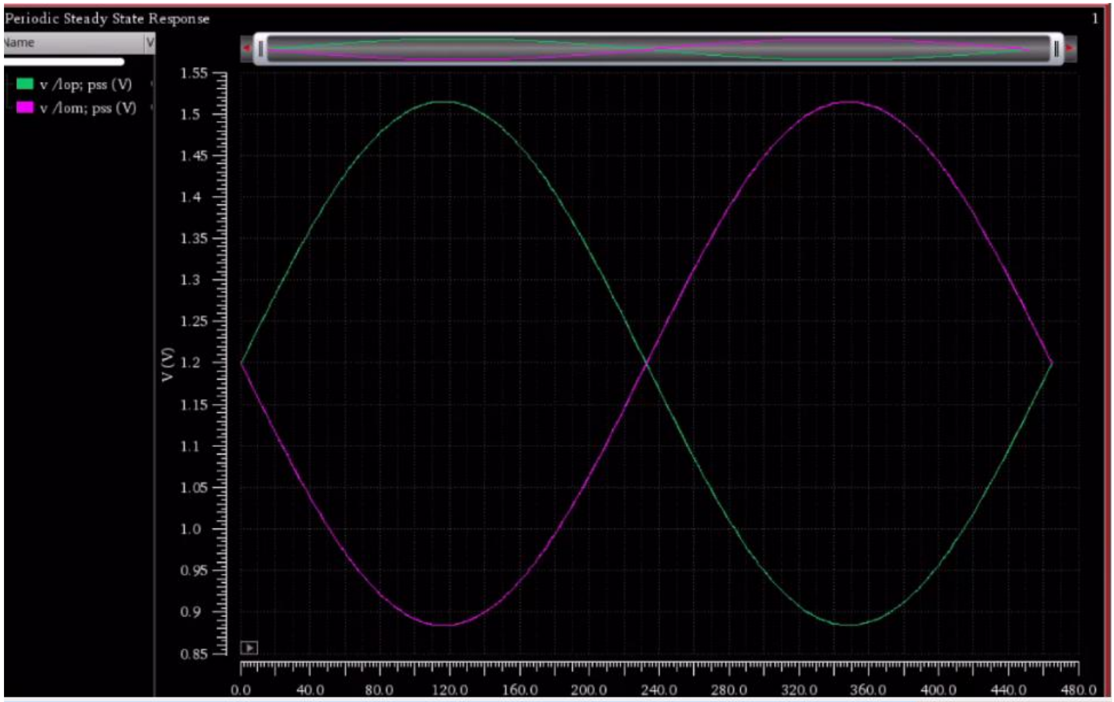
LO port


Gain=0.5
50Ω only for matching
PORT0
r:50
R2
r=50
egain=500m
E1
egain=500m
vdc=1.2
gnd
gnd
gnd
1.2V Bias

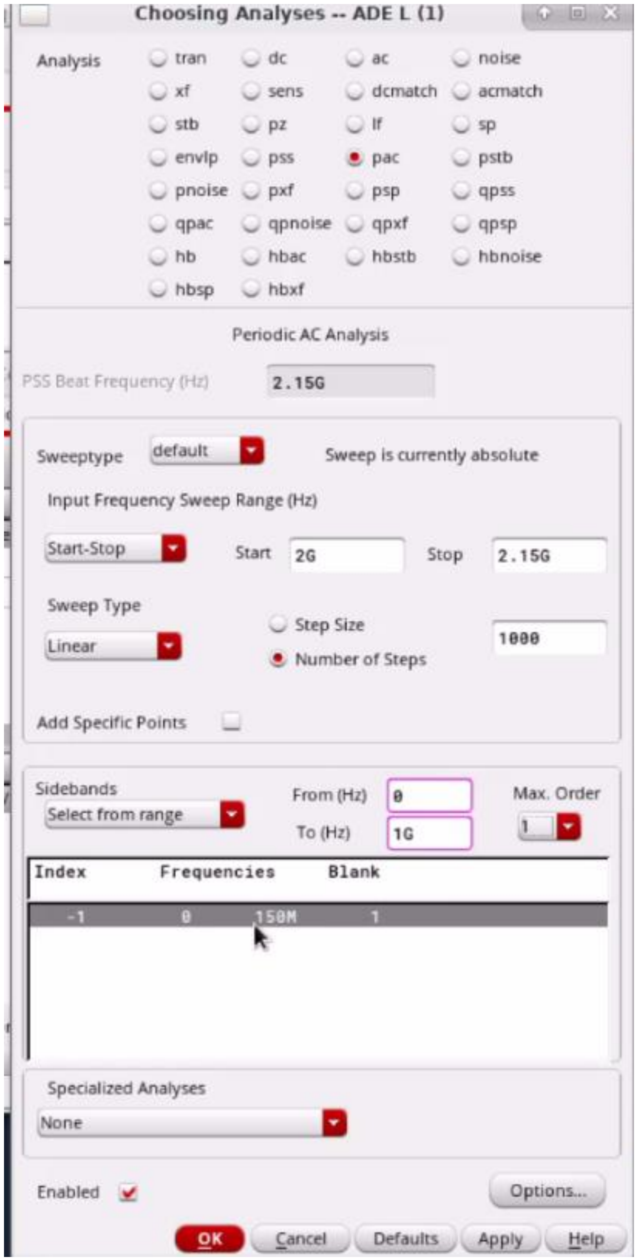

Edit Object Properties
Browse
Reset Instance Labels Dis
Property
Value
Library Name
analogLib
Cell Name
psin
View Name
symbol
Instance Name
PORT0
Add
Delete
Change All
User Property
Master Value
lvsIgnore
TRUE
CDF Parameter
Value
Frequency name
Second frequency name
Noise file name
Number of noise/freq pairs
0
Resistance
50 Ohms
Port number
DC voltage
Delay time
Sine DC level
Amplitude
Amplitude (dBm)
6
Initial phase for Sinusoid
Frequency
2.15G
Amplitude 2
Amplitude 2 (dBm)
Initial phase for Sinusoid 2
Frequency 2
FM modulation index

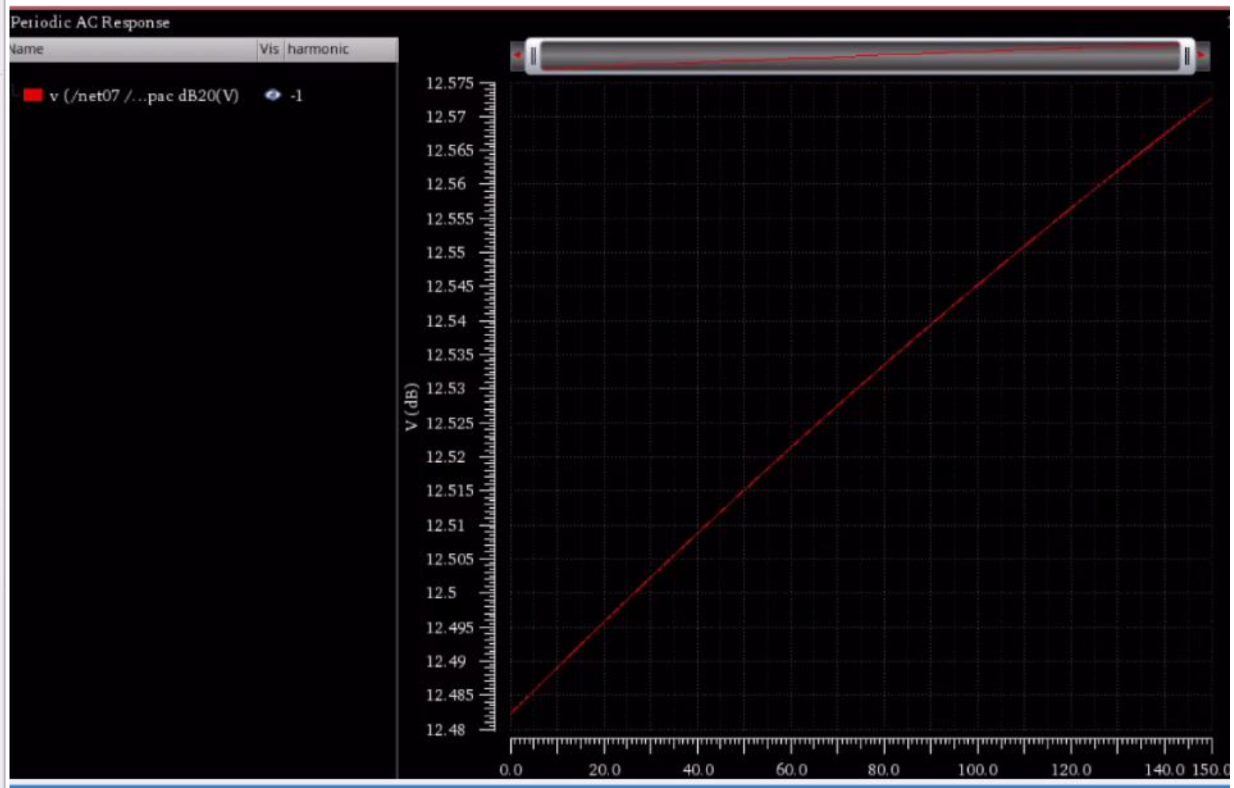
PSS simulation (periodic steady-state)



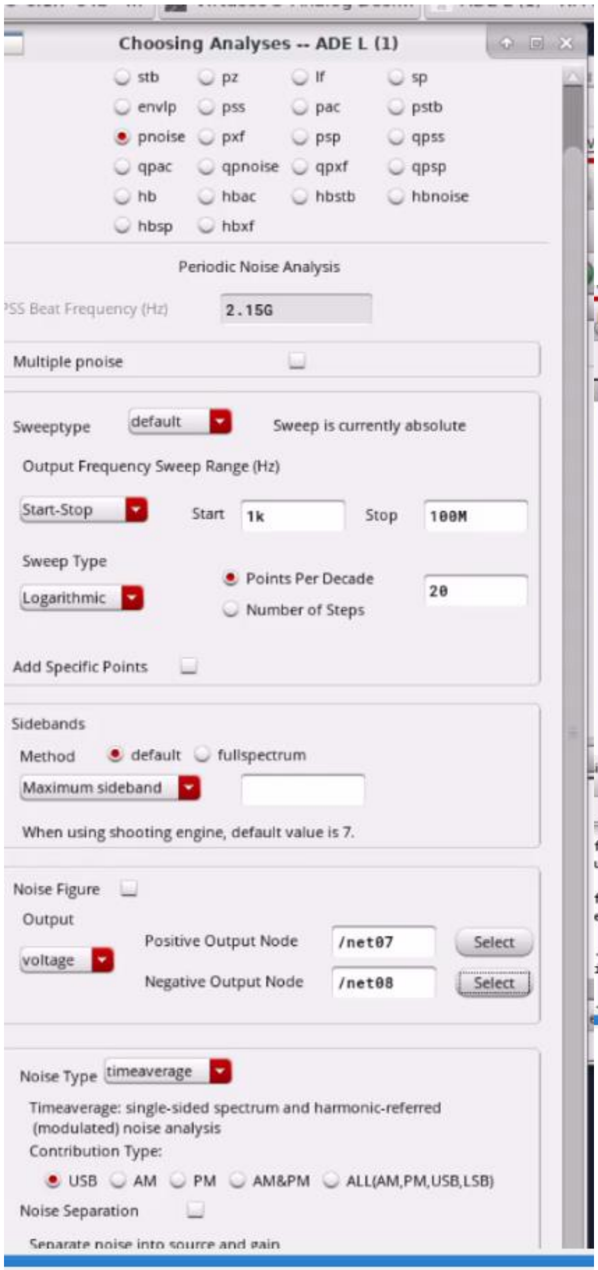


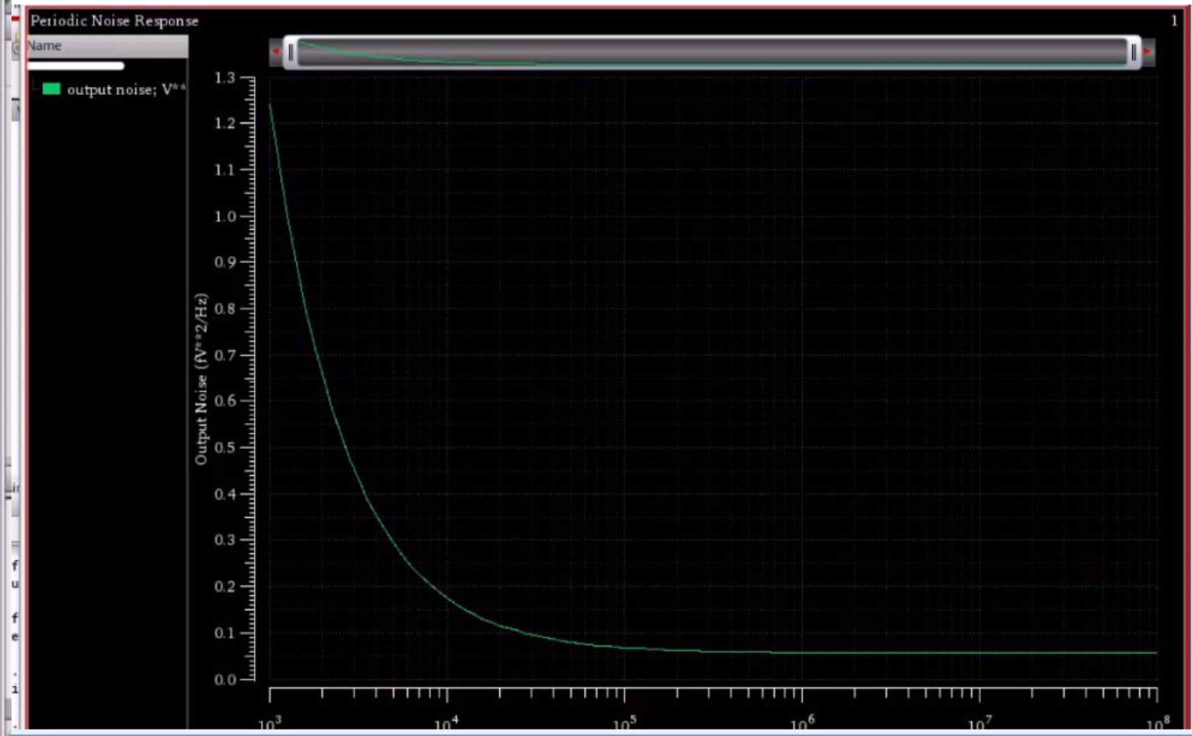
PAC simulation(periodic ac)





Pnoise Simulation





Question #1

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What are the key aspects to keep in mind when sizing switching pairs?

1. CMOS fabrication processes with channel lengths (minimum channel) in the nanoscale range are plagued by several second-order undesired effects, that alter the device's behavior and strongly limits the accuracy and effectiveness of the square-law equations traditionally used to determine the MOSFET operating point.

2.systematic approach for calculating the W/L transistor's ratios required for achieving the design specifications. The systematic approach exploits the gm/ID methodology and it is based on a unified treatment of all the regions of operation of the MOS transistor.

3. the framework extracts the transit frequency (fT), the intrinsic gain (gm/gds) and the current density ID/W versus the transconductance efficiency gm/ID.

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Question #1

What are the key aspects to keep in mind when sizing switching pairs?

4. The choice of the inversion level is essentially determined by a tradeoff between speed (fT), intrinsic gain and power efficiency and it depends on the target application.

increasing the gm/ID ratio increases the intrinsic gain but the width of the transistor and its associated capacitances are also increased, so the fT is reduced. On the other hand, for large values of gm/ID, the drain current decreases thus the DC power consumption is also reduced.

Question #2

What is the difference in the gain and noise performance of the mixer if we change the value of output resistance? Write your answer and computation.

1. **Impact on Gain :** Increasing the Rd(Load Resistance) Theoratically should increase the Out put Gain since the bais point is set and the tail current in the Mb (M1) resistor is fixed the gain no longer increase the beyond the bais point for the given load 400ohm and the tail current 1.5m the out put IF port gain is 13db, load variation 100ohm to 10kohm implies the gain upto 3db to 13db but at the bais point and the load 400ohm it saturates with 13db

2. **Impact on the OutPut Noise:** since Load resistance and the Noise has flicker noise(white noise and 1/f2) have linear relationship , out put noise will increase with the load. Since transconductance of the tail current transistor also holds the linear relationship with the noise the variation of the load impacts on the bais current and the bais current changes the GM of the tail current transistor this makes almost noise in control not to explode too much for the load variation 100ohm to 10K ohm implies the output noise 120a v2/hz to 1.2f V2/Hz is

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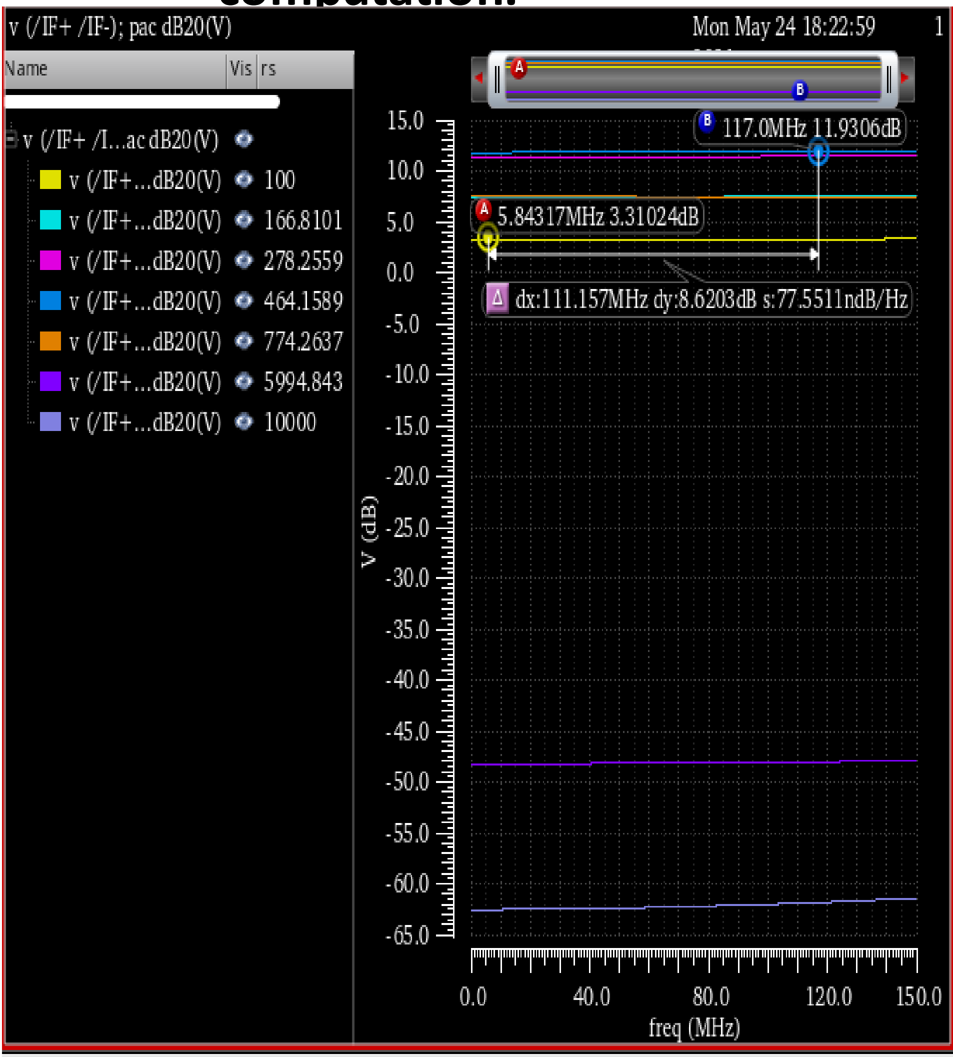
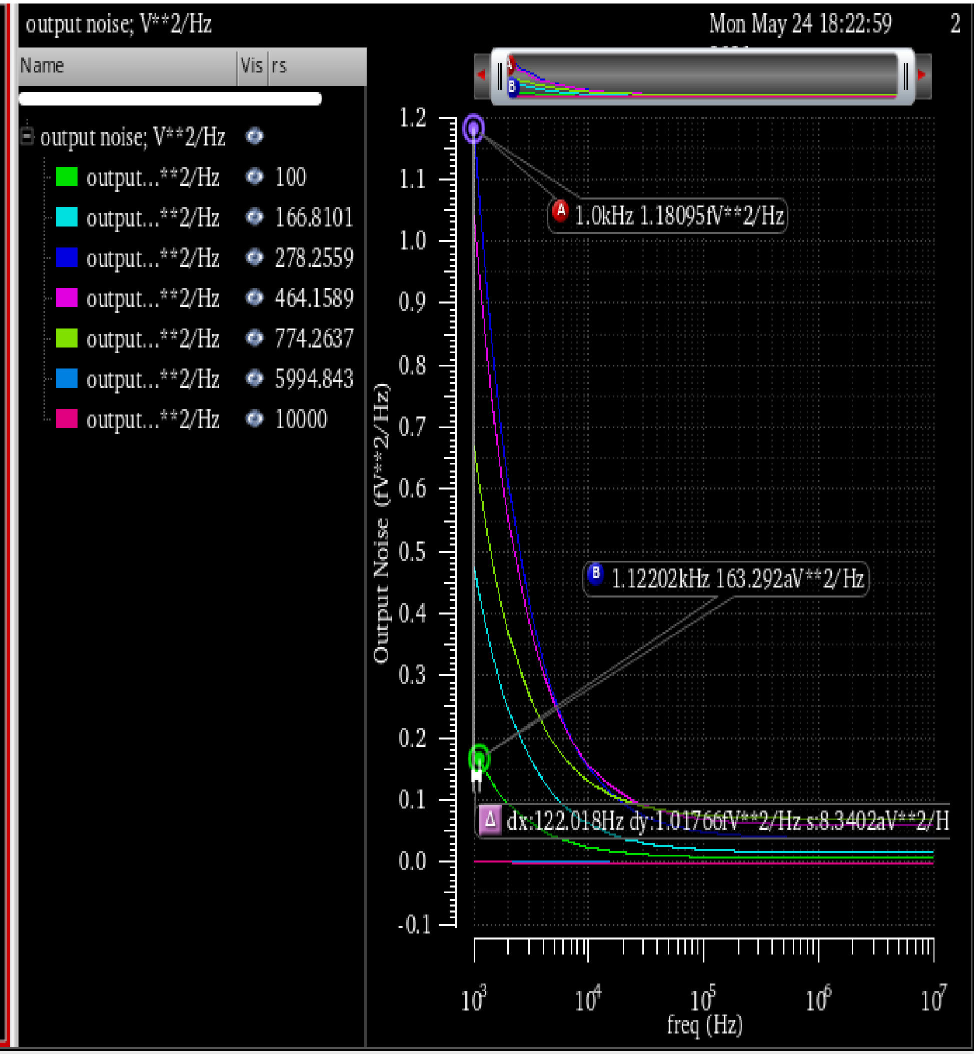
Question #2

What is the difference in the gain and noise performance of the mixer if we change the value of output resistance? Write your answer and computation.





Question #3

What is the difference in the gain and noise performance of the mixer if we change the size of the switching pair? Write your answer and computation.

Since the gain of the output depends on the voltage drop across the load as the switching pair width increase the the gain aslo increases but on counter balance the output noise also increase same same ratio fro the given load 400ohm at the bais point 1.5mA tail current.

Sl.No	Width of the the switching paire (M)	Out put Gain (db)	OutPut noise (V**2/HZ)
1	10u - 1m	7db - 14db	1f - 8f

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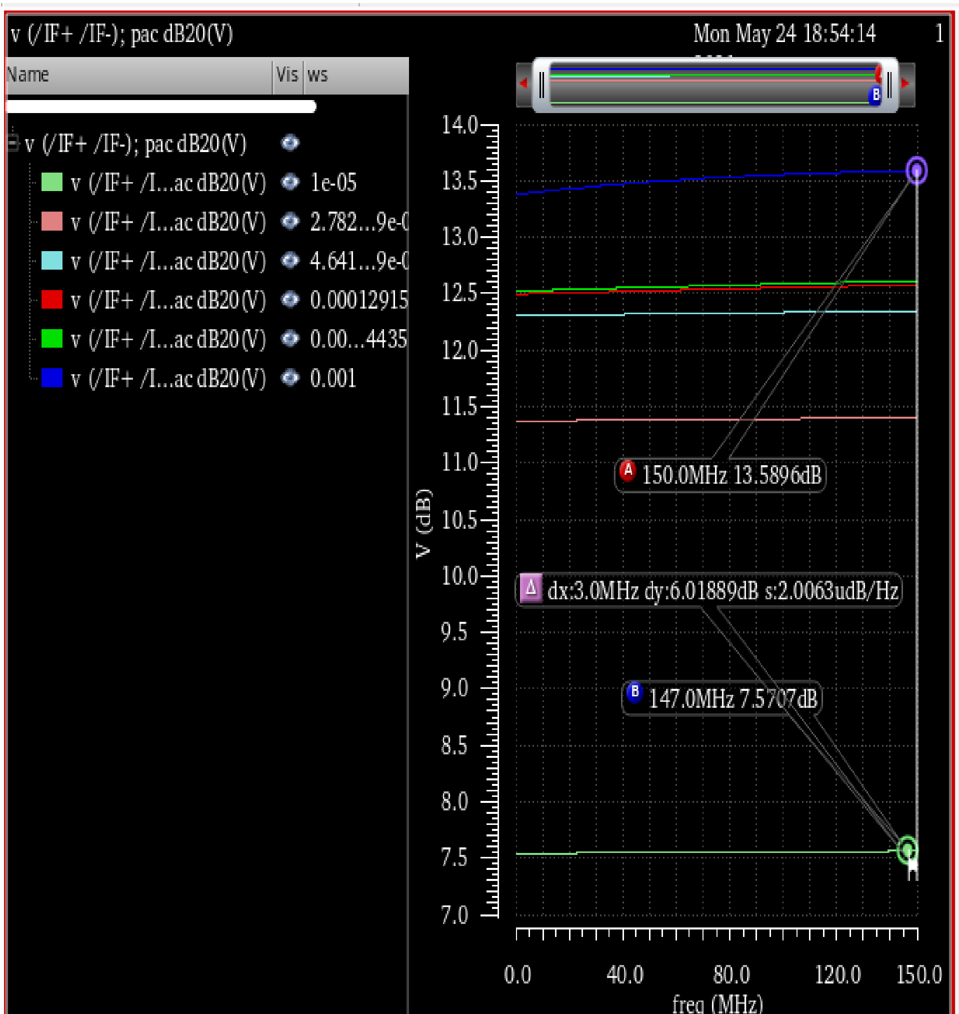
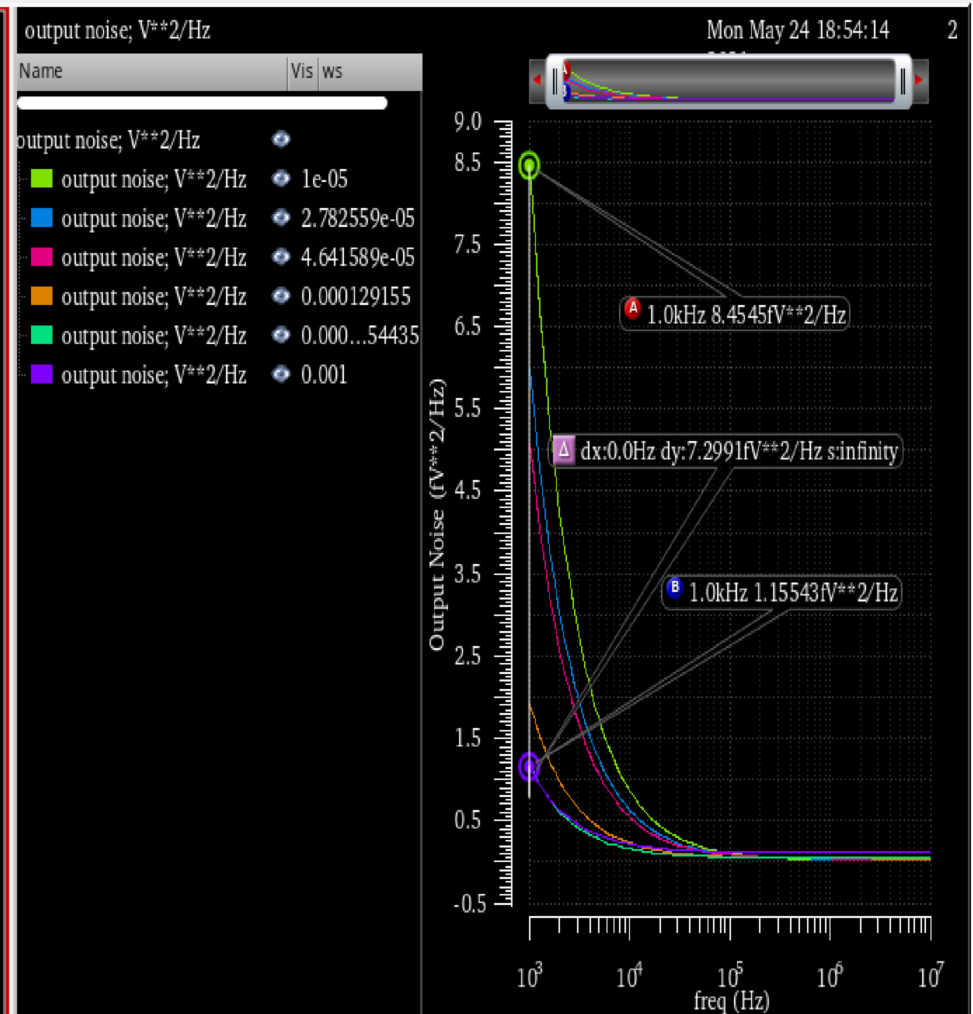
Question #3

What is the difference in the gain and noise performance of the mixer if we change the size of the switching pair? Write your answer and computation.





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Question #4

What is the difference in the gain and noise performance of the mixer if we change the amplitude of the oscillator? Write your answer and computation.

Increaing the feed local oscillator implitide directly IF output through the feed through as the lo amplitude srength increase the feed through increases, this generates output at the if port.

Sl.No	Oscillator gain	Out put Gain (db)	OutPut noise (V**2/HZ)
1	0.1 - 1.5	7db - 7db	116a - 6f
2	Optimum 0.5	13db	1.5f

Question #4

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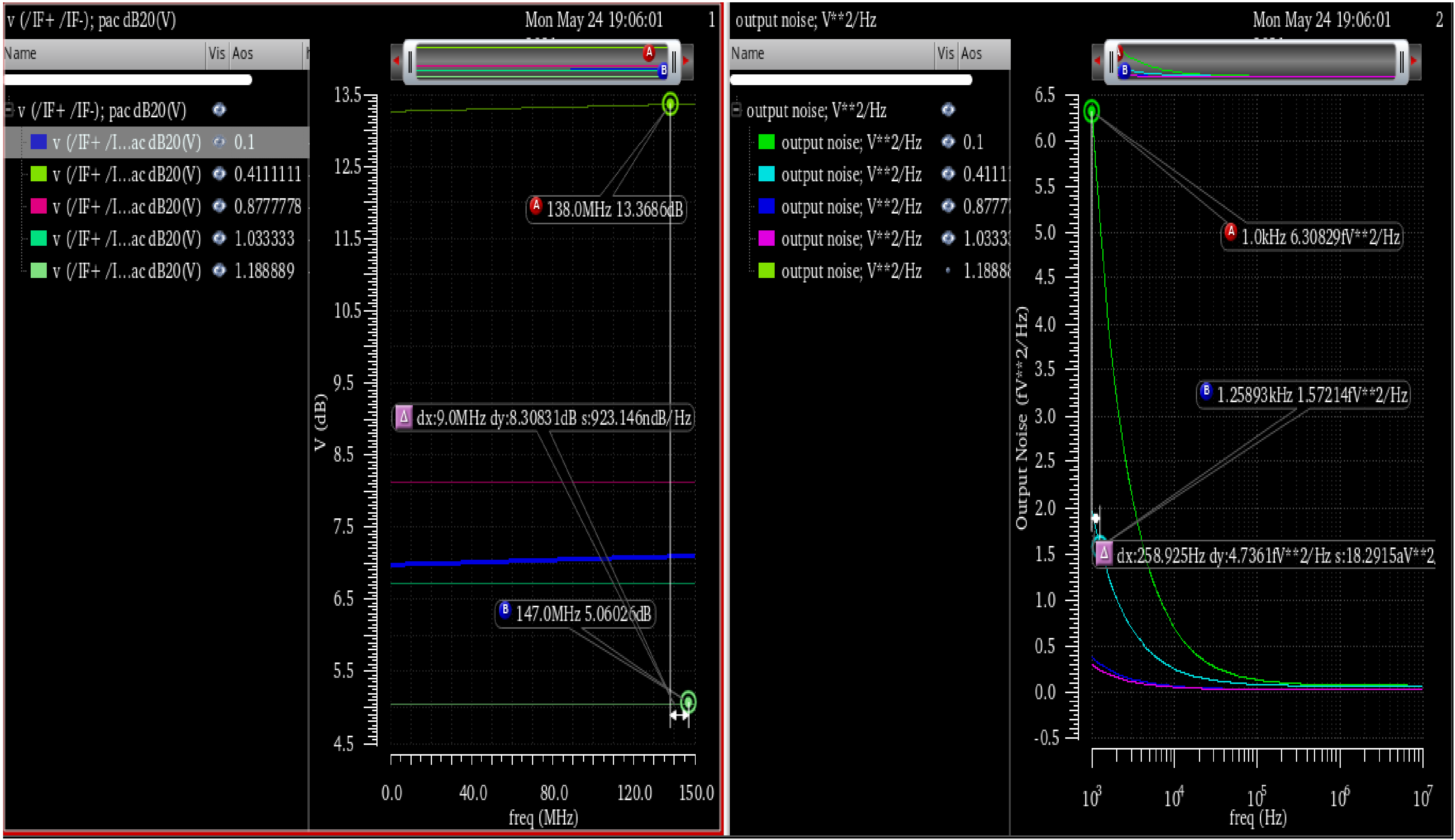
What is the difference in the gain and noise performance of the mixer if we change the amplitude of the oscillator? Write your answer and



Question #4

Conclusion