

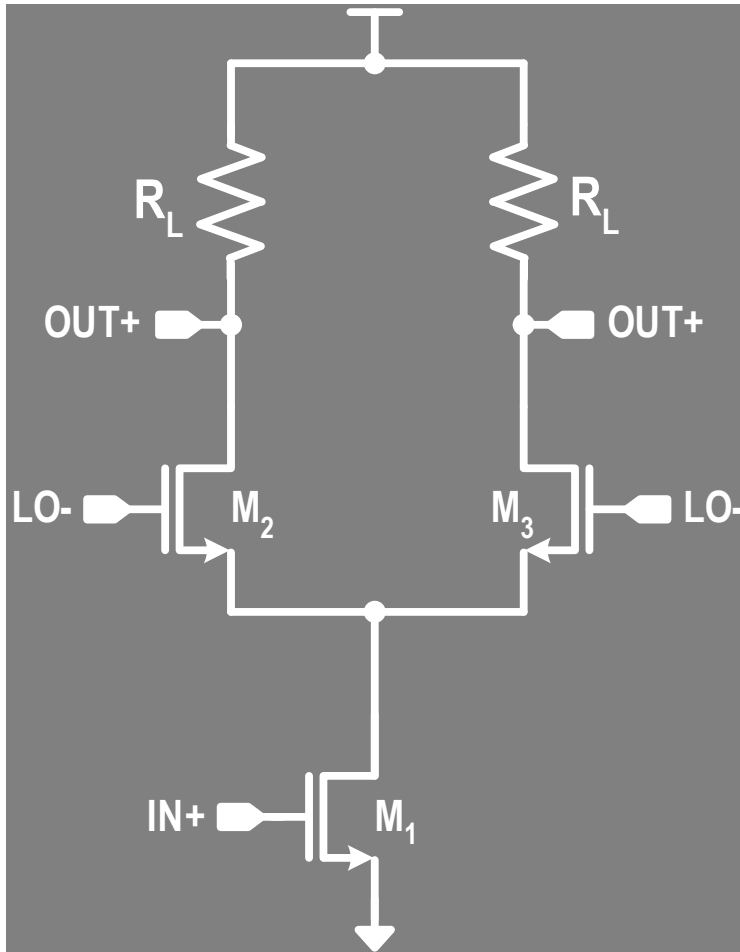
Gilbert Cell Mixer

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

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

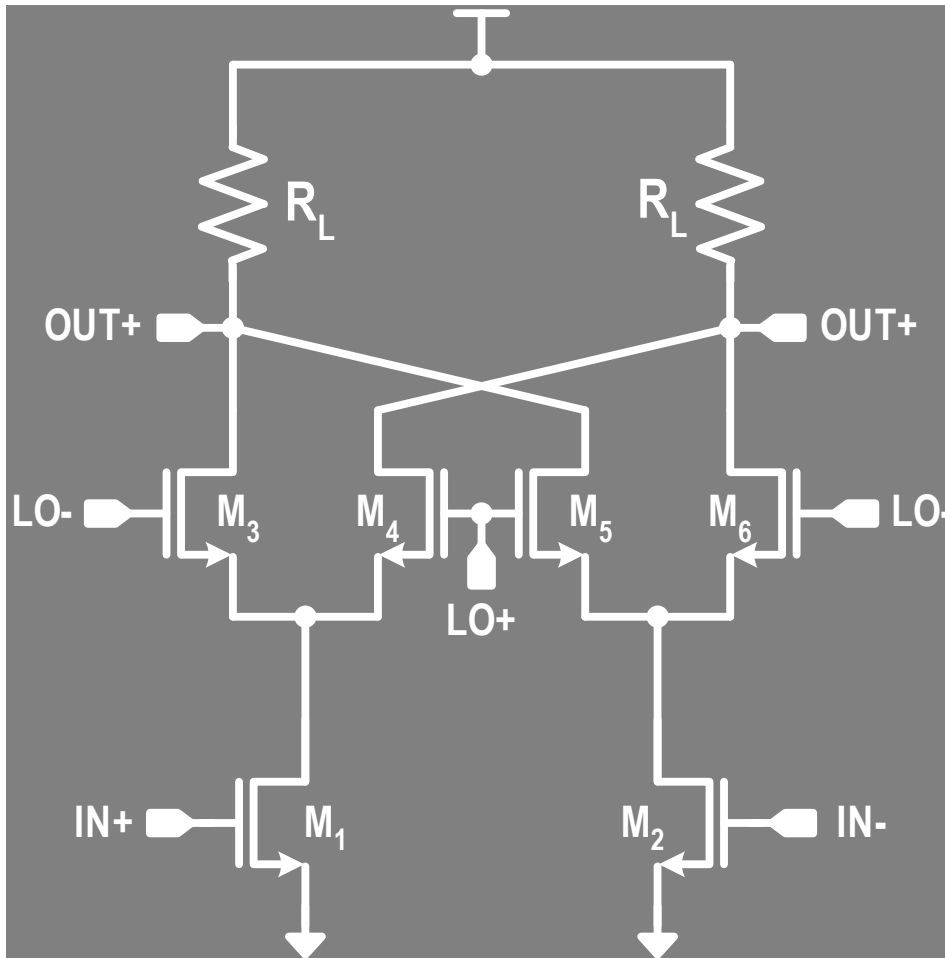
Transconductance
gain

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

Voltage Gain

Gilbert Cell Active Mixer

“double - balanced” version



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

Drain Current
of M1

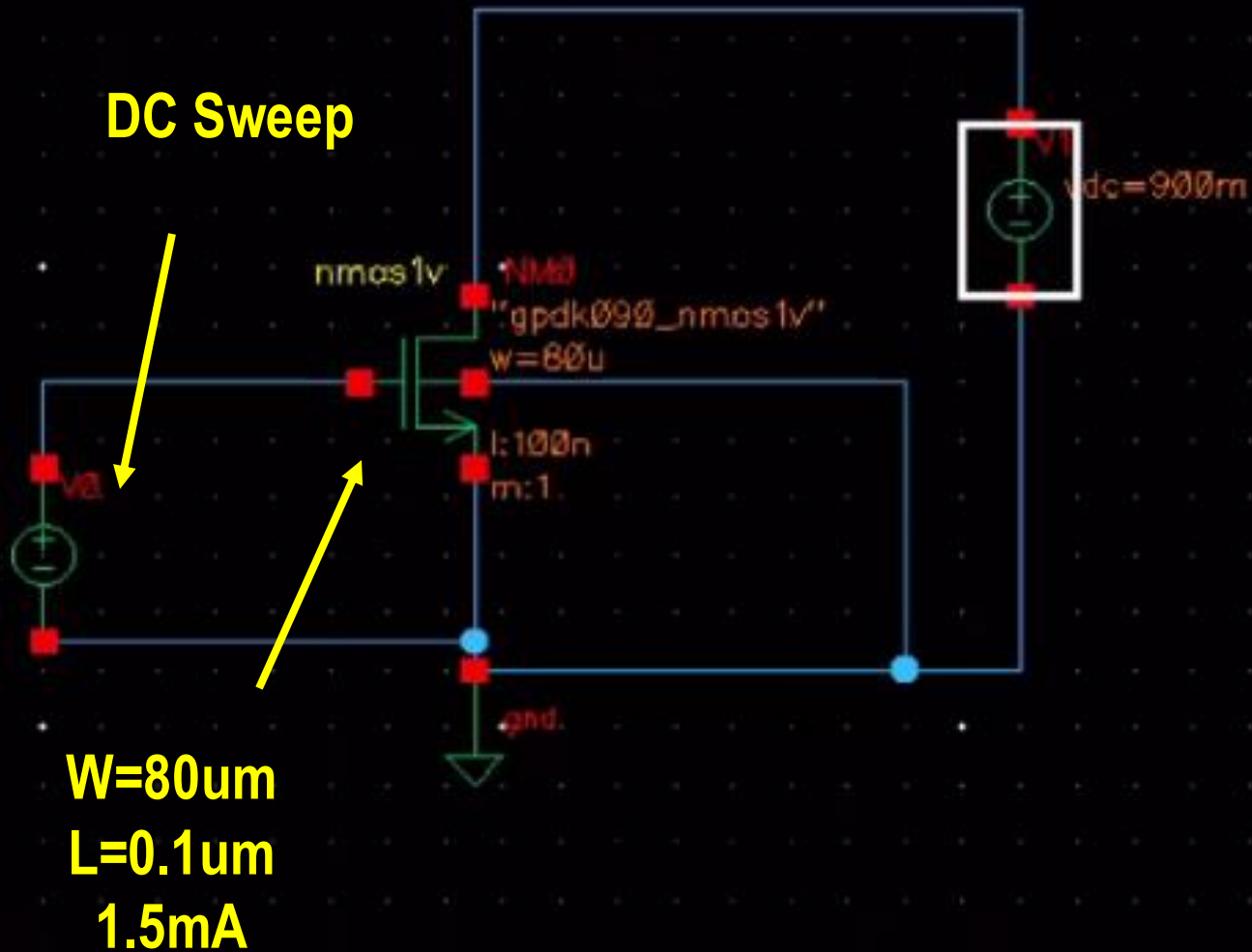
$$i_{RF,M2} = -g_{m2} \frac{V_{IN}}{2}$$

Drain Current
of M2

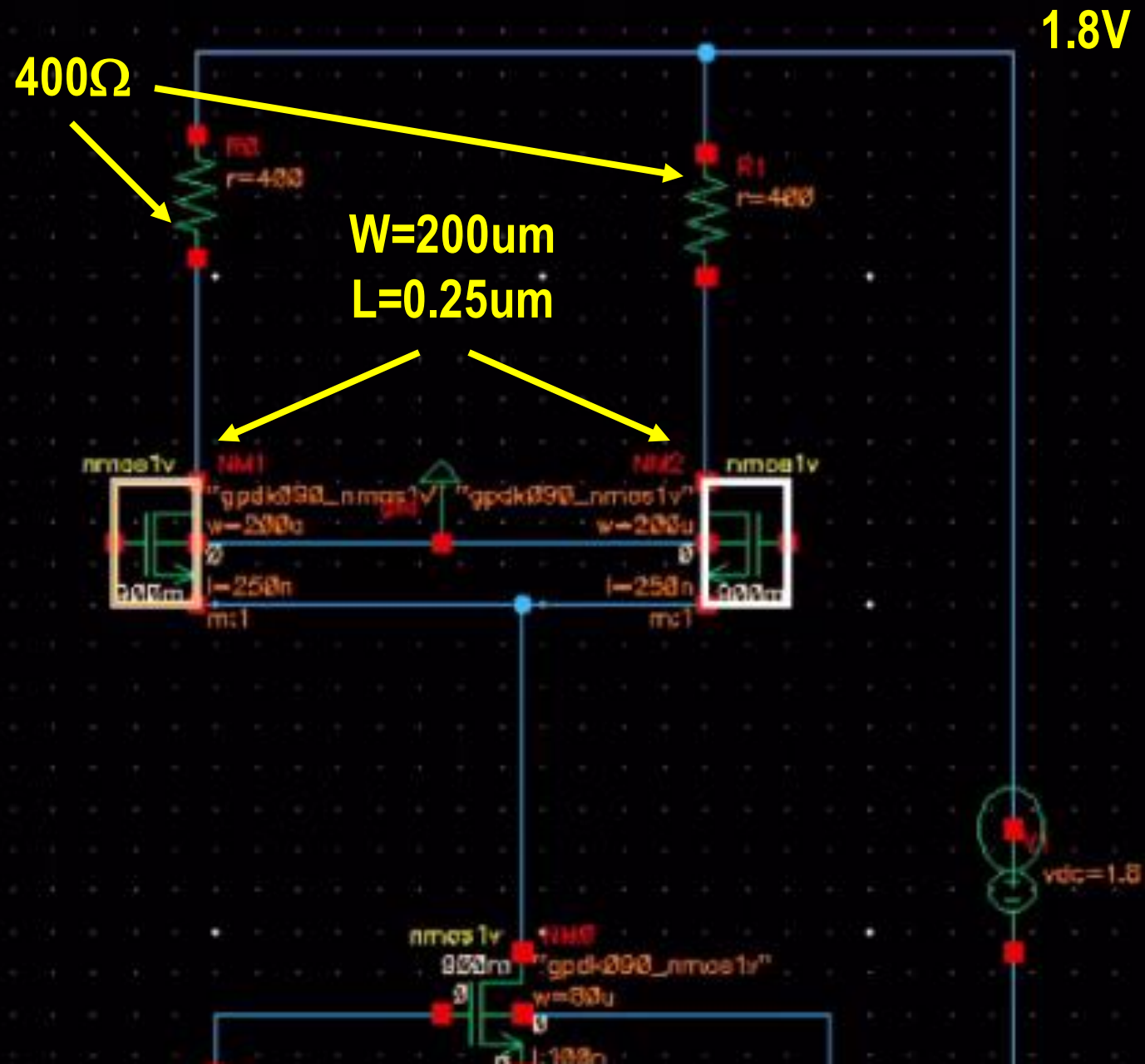
$$\frac{V_{OUT}}{V_{IN}} = g_{m1} \frac{2}{\pi} R_L$$

Voltage Gain

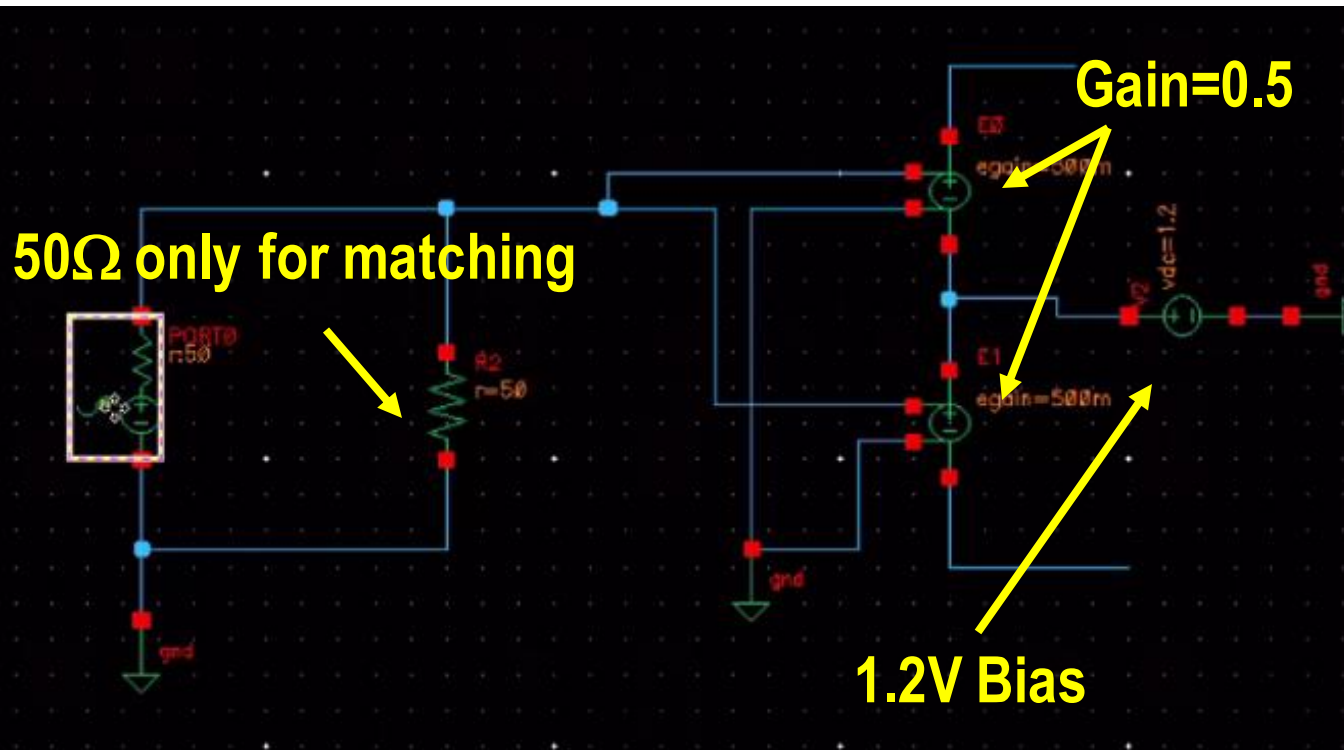
Transconductor Bias



Switching pair and load



LO port



Edit Object Properties

Property	Value
Library Name	analogLib
Cell Name	psin
View Name	symbol
Instance Name	PORT0

Change All ☐ User Property ☐ Ivignore ☐ Master Value ☐ 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)

Choosing Analyses -- ADE L (1)

Analysis

☐ tran ☐ dc ☐ ac ☐ noise

☐ xf ☐ sens ☐ dcmatch ☐ acmatch

☐ stb ☐ pz ☐ lf ☐ sp

☐ envlp ☒ pss ☐ pac ☐ pstb

☐ pnoise ☐ pxf ☐ psp ☐ qpss

☐ qpac ☐ qpnoise ☐ qpxf ☐ qpsp

☐ hb ☐ hbac ☐ hbstb ☐ hbnoise

☐ hbsp ☐ hbxf

Periodic Steady State Analysis

Engine ☒ Shooting ☐ Harmonic Balance

Fundamental Tones

#	Name	Expr	Value	Signal	SrcId
1		2.15G	2.15G	Large	PORT0

2.15G 2.15G Large PORT0

Clear/Add Delete Update From Hierarchy

☒ Beat Frequency ☐ Beat Period

2.15G Auto Calculate ☒

Output harmonics

Number of harmonics 10

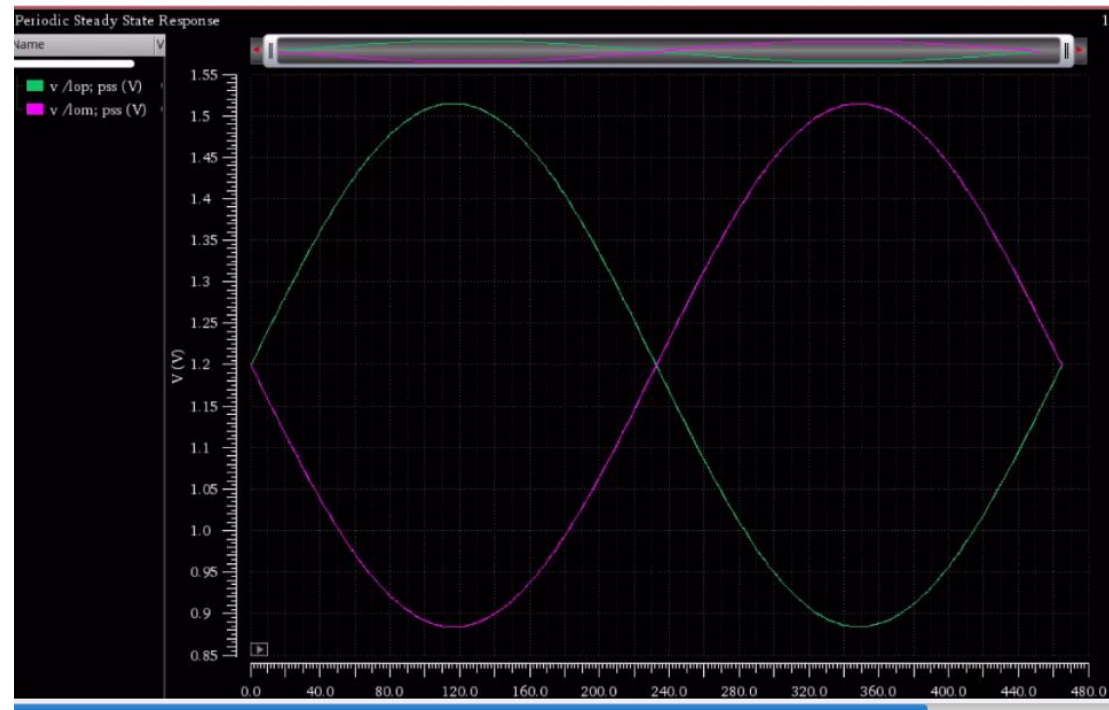
Accuracy Defaults (errpreset)

☒ conservative ☐ moderate ☐ liberal

Transient-Aided Options

Run transient? ☒ Yes ☐ No ☐ Decide automatically

Detect Steady State ☐ Stop Time (tstab)



PAC simulation(periodic ac)

Choosing Analyses -- ADE L (1)

Analysis

<input type="radio"/> tran	<input type="radio"/> dc	<input type="radio"/> ac	<input type="radio"/> noise
<input type="radio"/> xf	<input type="radio"/> sens	<input type="radio"/> dcmatch	<input type="radio"/> acmatch
<input type="radio"/> stb	<input type="radio"/> pz	<input type="radio"/> lf	<input type="radio"/> sp
<input type="radio"/> envlp	<input type="radio"/> pss	<input checked="" type="radio"/> pac	<input type="radio"/> pstb
<input type="radio"/> pnoise	<input type="radio"/> pxf	<input type="radio"/> psp	<input type="radio"/> qpss
<input type="radio"/> qpac	<input type="radio"/> qpnoise	<input type="radio"/> qpxf	<input type="radio"/> qpssp
<input type="radio"/> hb	<input type="radio"/> hbac	<input type="radio"/> hbstb	<input type="radio"/> hbnoise
<input type="radio"/> hbsp	<input type="radio"/> hbxf		

Periodic AC Analysis

PSS Beat Frequency (Hz)

Sweep type Sweep is currently absolute

Input Frequency Sweep Range (Hz)

Start-Stop Start Stop

Sweep Type

Linear ☐ Step Size

☒ Number of Steps

Add Specific Points ☐

Sidebands

Select from range From (Hz) To (Hz) Max. Order

Index	Frequencies	Blank
-1	0	150M

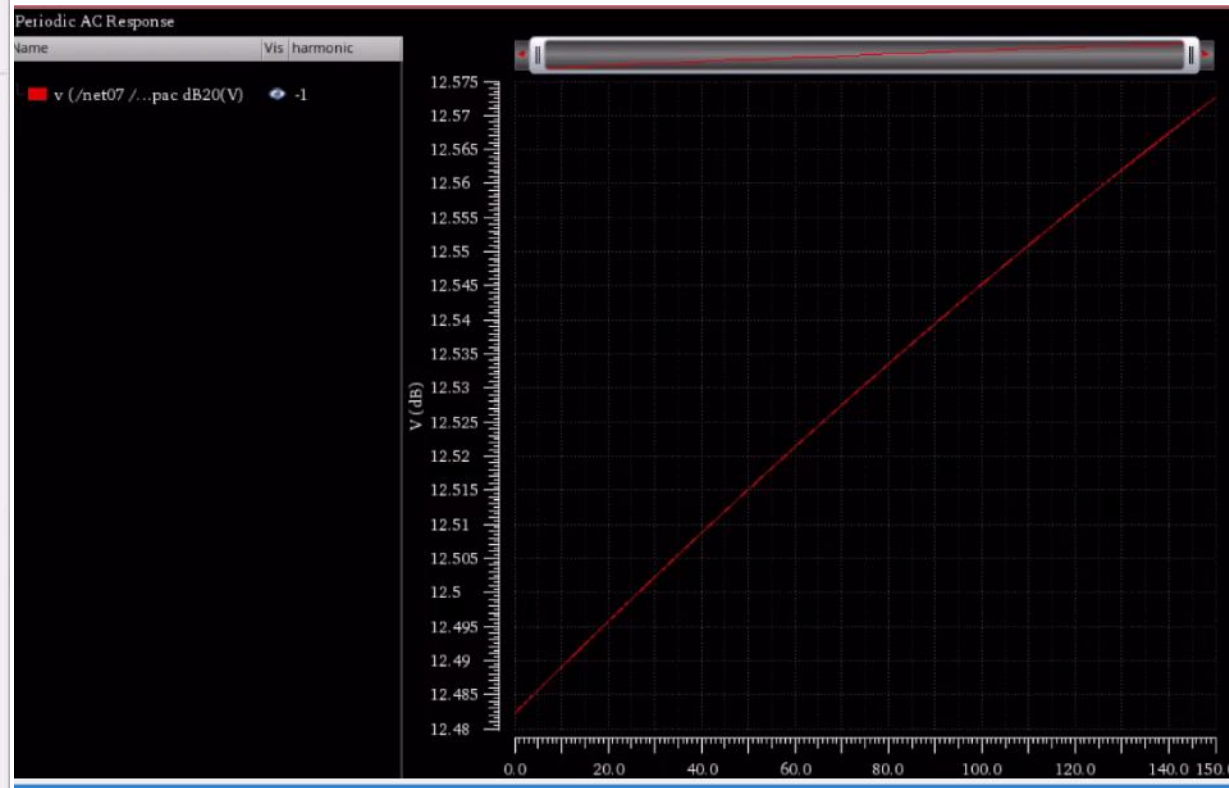
Specialized Analyses

None

Enabled ☒

Options...

OK Cancel Defaults Apply Help



Pnoise Simulation

Choosing Analyses -- ADE L (1)

<input type="radio"/> stb	<input type="radio"/> pz	<input type="radio"/> lf	<input type="radio"/> sp
<input type="radio"/> envlp	<input type="radio"/> pss	<input type="radio"/> pac	<input type="radio"/> pstb
<input checked="" type="radio"/> pnoise	<input type="radio"/> pxf	<input type="radio"/> psp	<input type="radio"/> qpss
<input type="radio"/> qpac	<input type="radio"/> qpnoise	<input type="radio"/> qpxf	<input type="radio"/> qpssp
<input type="radio"/> hb	<input type="radio"/> hbac	<input type="radio"/> hbstb	<input type="radio"/> hbnoise
<input type="radio"/> hbsp	<input type="radio"/> hbx		

Periodic Noise Analysis

PSS Beat Frequency (Hz)

Multiple pnoise ☐

Sweep type Sweep is currently absolute

Output Frequency Sweep Range (Hz)

Start-Stop Start Stop

Sweep Type

☒ Logarithmic ☐ Points Per Decade ☐ Number of Steps

Add Specific Points ☐

Sidebands

Method ☒ default ☐ fullspectrum

Maximum sideband

When using shooting engine, default value is 7.

Noise Figure ☐

Output

☒ voltage ☐ Positive Output Node

☐ Negative Output Node

Noise Type ☒ timeaverage

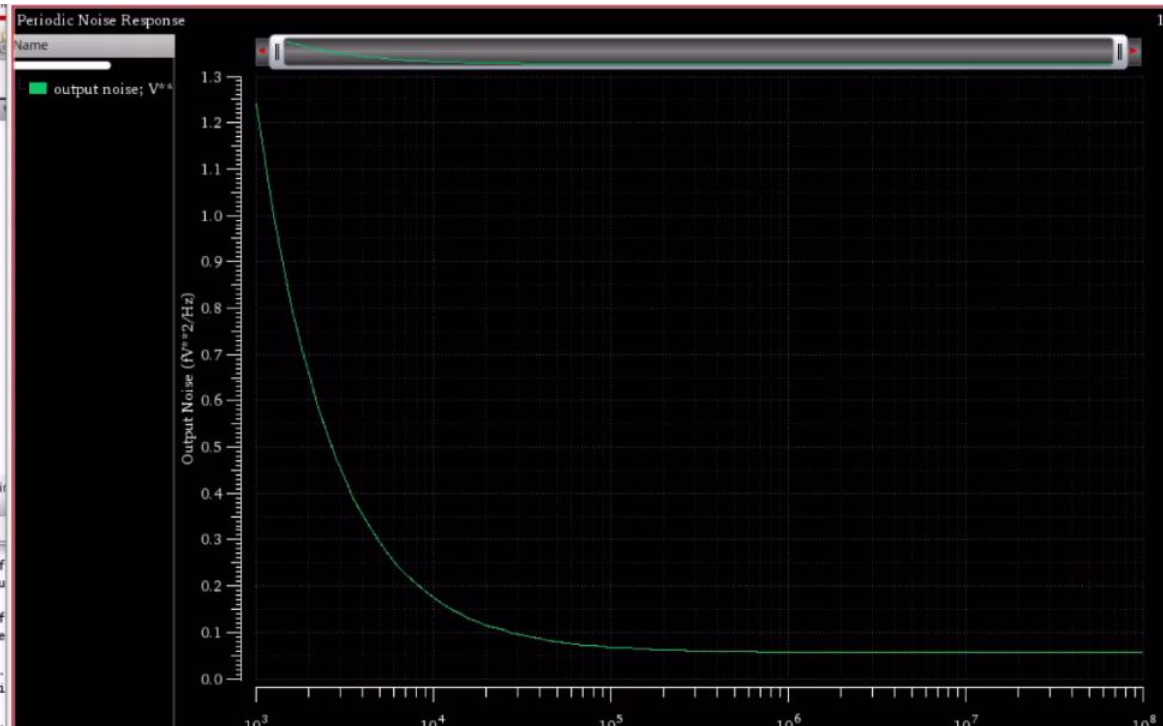
Timeaverage: single-sided spectrum and harmonic-referred (modulated) noise analysis

Contribution Type:

☒ USB ☐ AM ☐ PM ☐ AM&PM ☐ ALL(AM,PM,USB,LSB)

Noise Separation ☐

Separate noise into source and gain





Question #1

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 g_m/I_D 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 (f_T), the intrinsic gain (g_m/g_{ds}) and the current density I_D/W versus the transconductance efficiency g_m/I_D .



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 (f_T), intrinsic gain and power efficiency and it depends on the target application.

increasing the g_m/I_D ratio increases the intrinsic gain but the width of the transistor and its associated capacitances are also increased, so the f_T is reduced. On the other hand, for large values of g_m/I_D , 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.

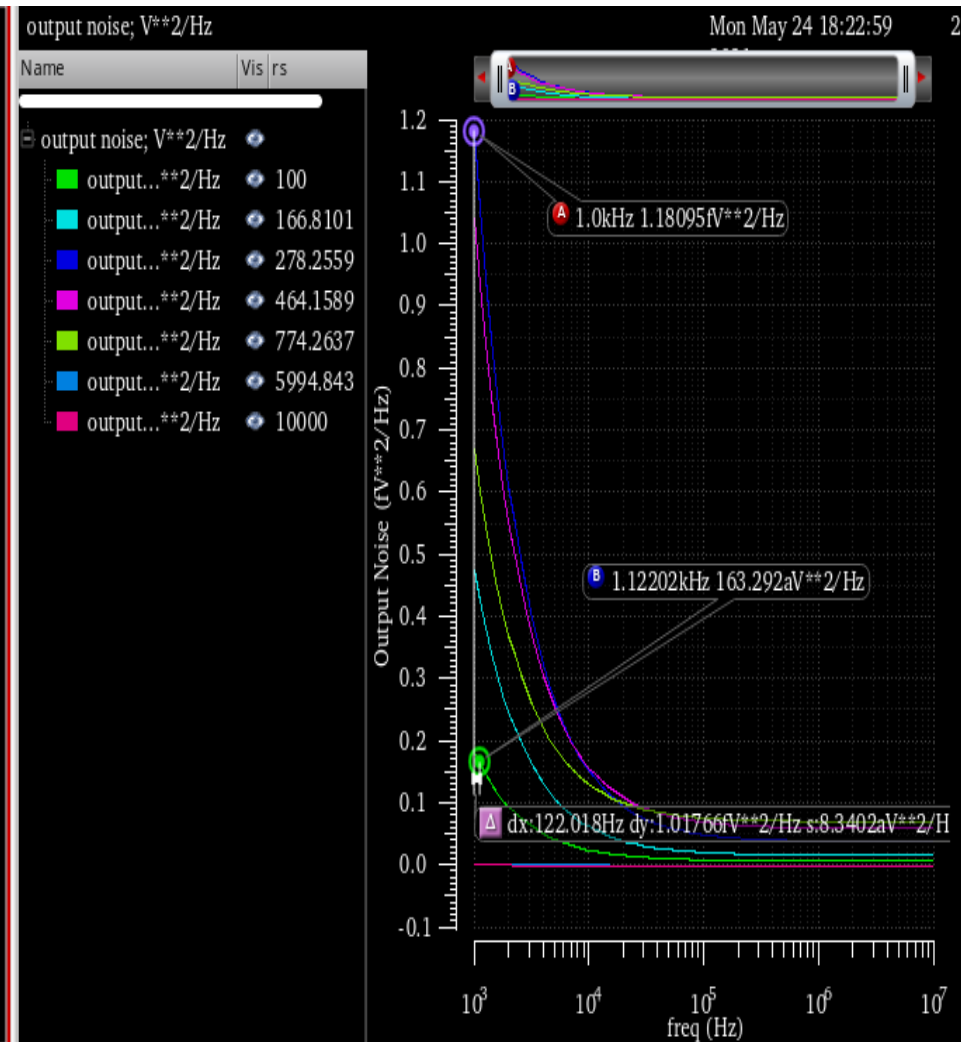
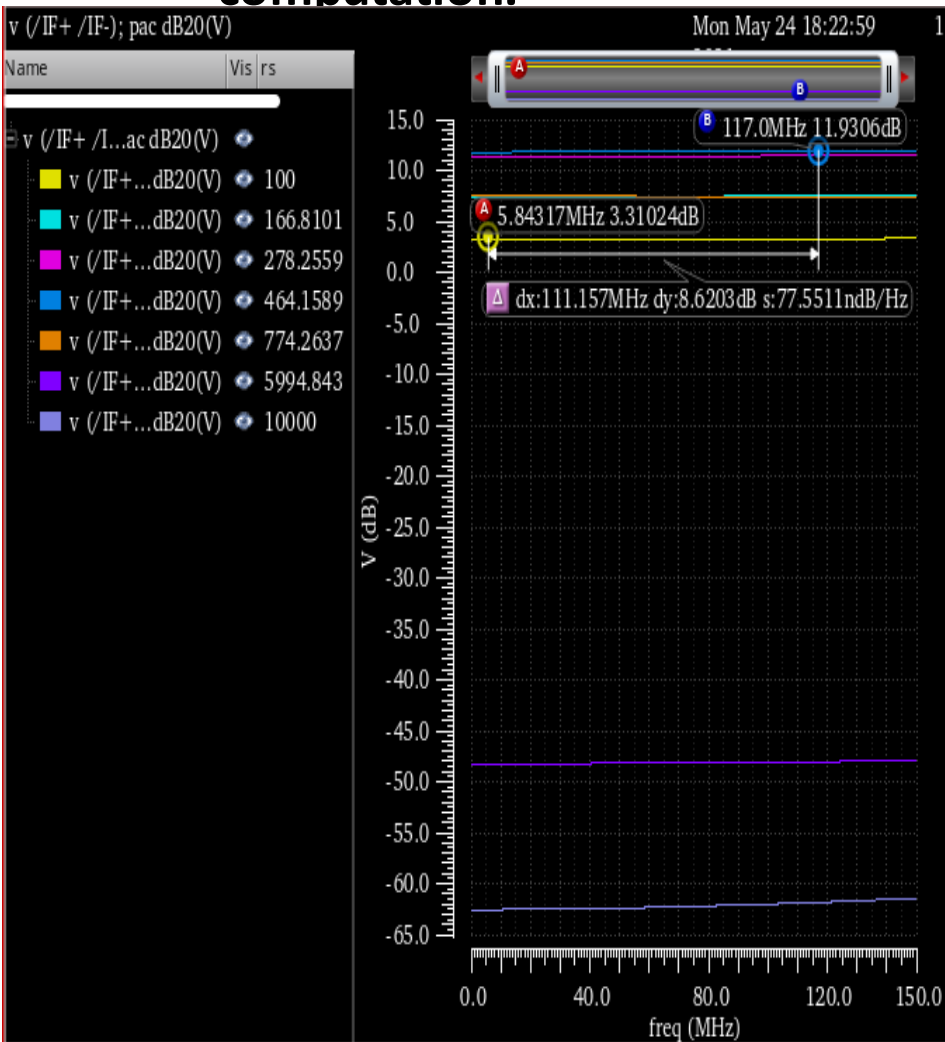
1. **Impact on Gain :** Increasing the R_d (Load Resistance) Theoratically should increase the Out put Gain since the bias point is set and the tail current in the M_b ($M1$) resistor is fixed the gain no longer increase the beyond the bias point for the given load 400ohm and the tail current 1.5m the out put IF port gain is 13db, load variation 100ohm to 10kohm implies the gain upto 3db to 13db but at the bias 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 $1/f^2$) 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 bias current and the bias 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 v^2/hz to 1.2f V^2/Hz is



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.



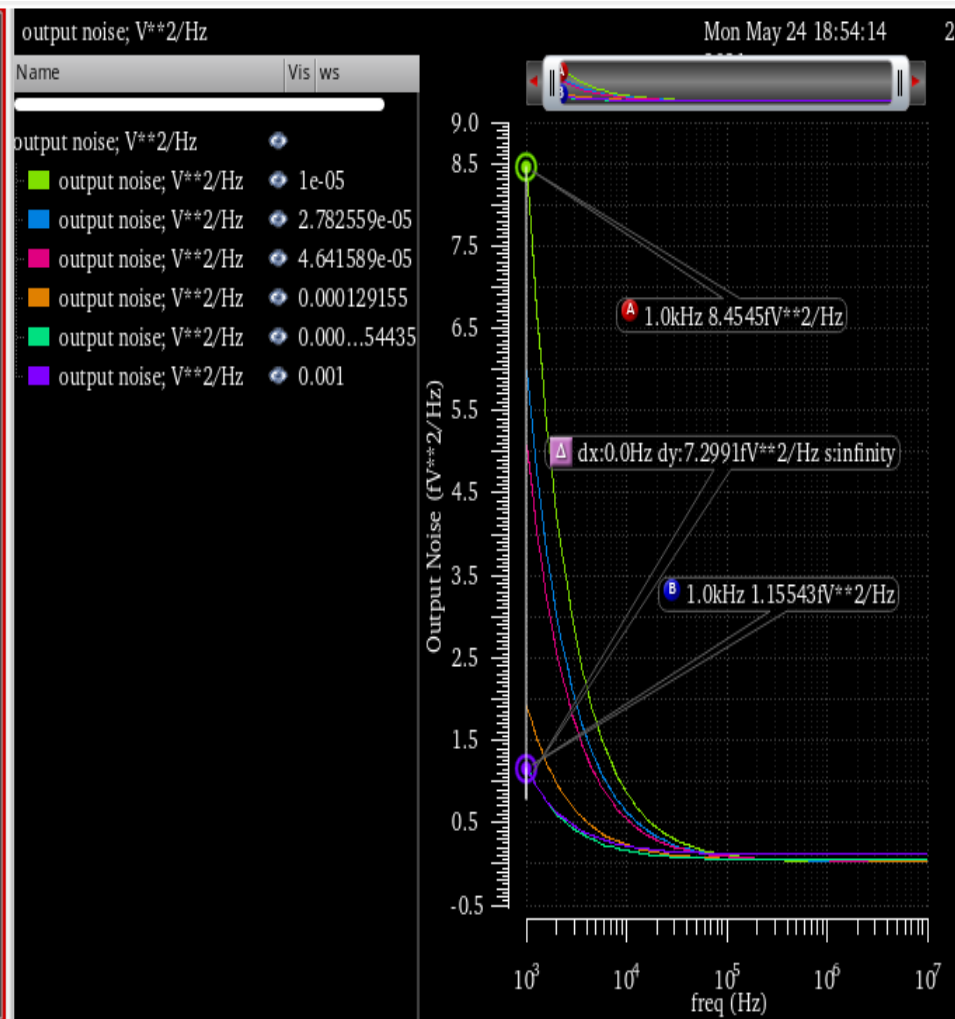


Question #3

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





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.

Increasing the feed local oscillator amplitude directly IF output through the feed through as the LO amplitude strength increases the feed through increases, this generates output at the IF port.

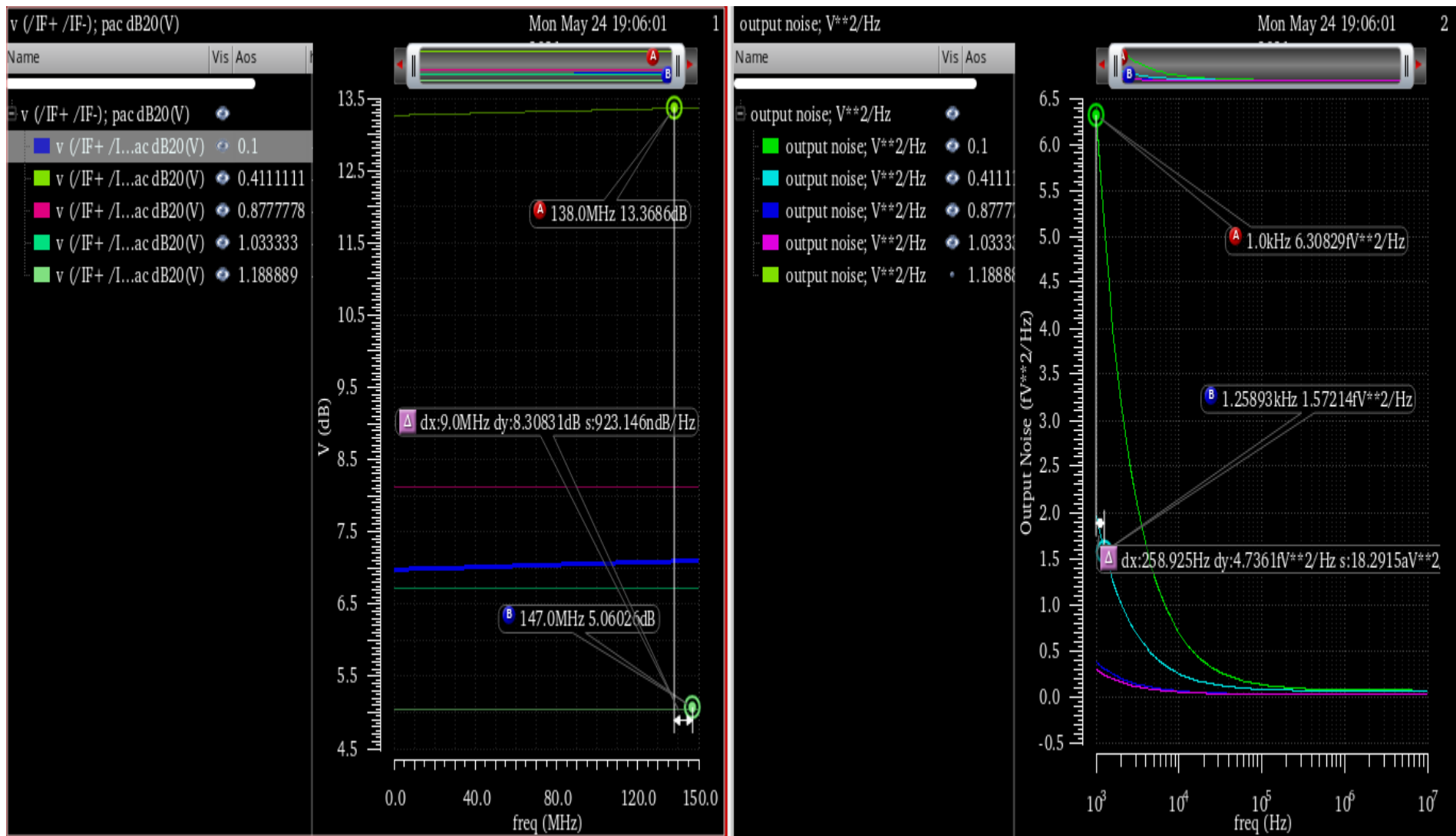
Sl.No	Oscillator gain	Out put Gain (db)	OutPut noise (V^2/HZ)
1	0.1 - 1.5	7db - 7db	116a - 6f
2	Optimum 0.5	13db	1.5f



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

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Conclusion

