



Cairo University



Faculty of Engineering

Advanced Topics in Electronics-1

Under supervision of:

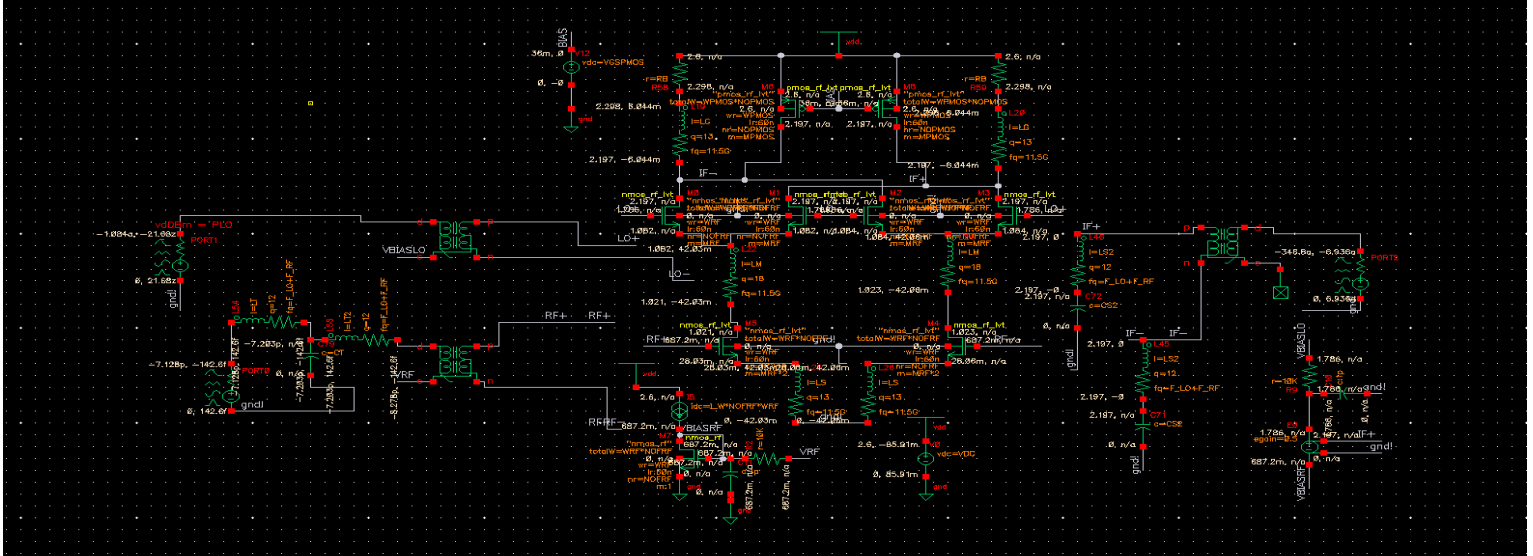
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Students Names:

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Schematic of design including the Voltages and currents

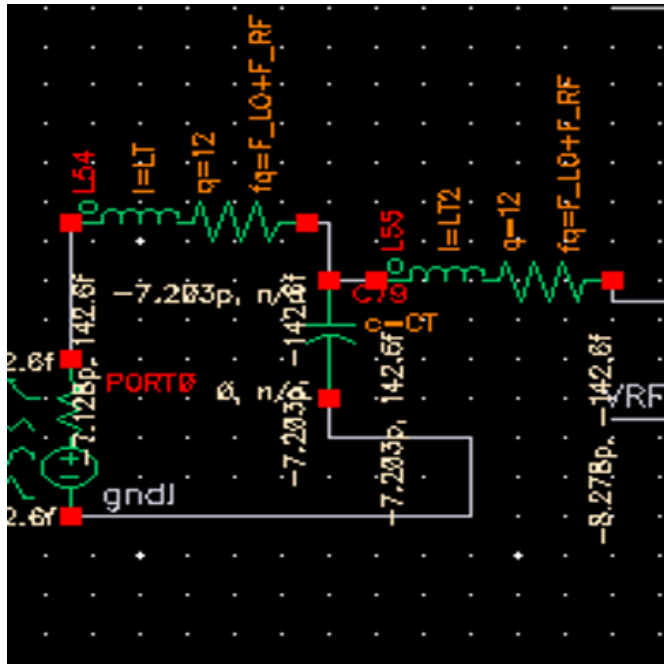


Global Variables		
<input checked="" type="checkbox"/>	I_W	95
<input checked="" type="checkbox"/>	MRF	6
<input checked="" type="checkbox"/>	NOFRF	32
<input checked="" type="checkbox"/>	VDC	2.6
<input checked="" type="checkbox"/>	WLO	600n
<input checked="" type="checkbox"/>	WRF	600n
<input checked="" type="checkbox"/>	WTAIL	600n
<input checked="" type="checkbox"/>	VGSPMOS	600m
<input type="checkbox"/>	F_LO	F_RF-1
<input type="checkbox"/>	F_RF	12G
<input checked="" type="checkbox"/>	I_WLO	50
<input type="checkbox"/>	Pin	-40
<input checked="" type="checkbox"/>	RD	1
<input checked="" type="checkbox"/>	WPMOS	600n
<input checked="" type="checkbox"/>	NOBIAS	4
<input type="checkbox"/>	PLO	0
<input checked="" type="checkbox"/>	LG	3n
<input checked="" type="checkbox"/>	LS	120p
<input checked="" type="checkbox"/>	CS	200f
<input checked="" type="checkbox"/>	RE	100
<input checked="" type="checkbox"/>	NPMOS	32
<input checked="" type="checkbox"/>	WP	1
<input checked="" type="checkbox"/>	MPMOS	5
<input checked="" type="checkbox"/>	IDC	1u
<input checked="" type="checkbox"/>	RB	50
<input checked="" type="checkbox"/>	CB	10f
<input checked="" type="checkbox"/>	RBIAS	100
<input checked="" type="checkbox"/>	NOPMOS	32

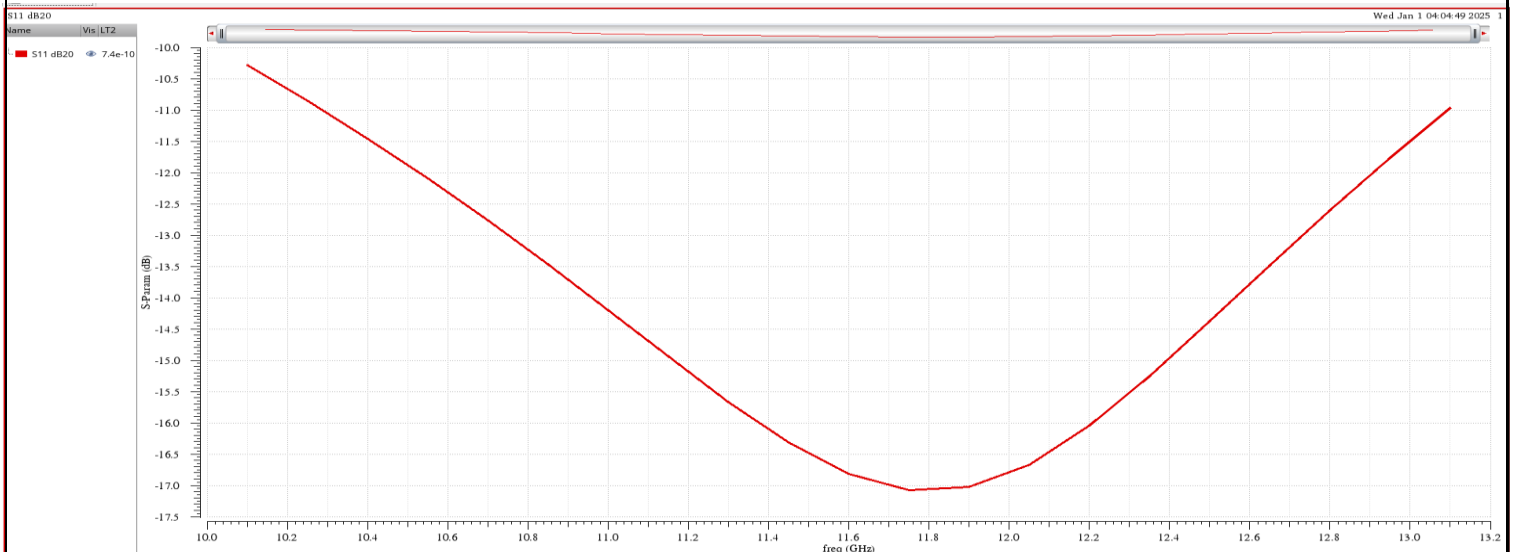
<input checked="" type="checkbox"/>	RBIAS	100
<input checked="" type="checkbox"/>	NOPMOS	32
<input checked="" type="checkbox"/>	LM	360p
<input checked="" type="checkbox"/>	CL	400f
<input checked="" type="checkbox"/>	LE	1
<input checked="" type="checkbox"/>	NOFR	1
<input checked="" type="checkbox"/>	CS2	41f
<input checked="" type="checkbox"/>	LS2	1.8n
<input type="checkbox"/>	F_IF	1:1G:3G
<input checked="" type="checkbox"/>	CP	10f
<input checked="" type="checkbox"/>	VGSBIAS	36m
<input checked="" type="checkbox"/>	LR	300p
<input checked="" type="checkbox"/>	NOFBIAS	32
<input checked="" type="checkbox"/>	CT	300f
<input checked="" type="checkbox"/>	LT	50p
<input checked="" type="checkbox"/>	LT2	720p
<input checked="" type="checkbox"/>	F_RF2	12G
<input type="checkbox"/>	F_RFtwo	F_RF+1

All variable used in the schematic with sizing

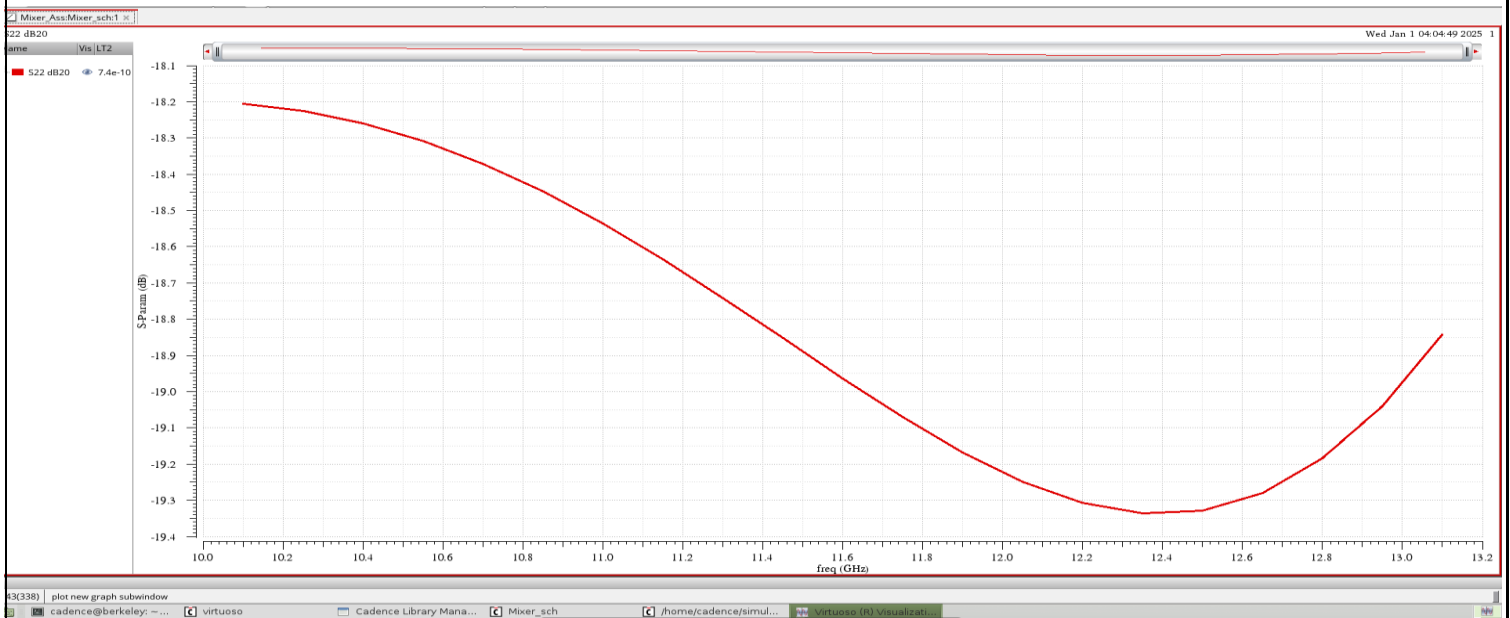
In the previous design I used current bleeding technique using a pmos to increase linearity and decrease current drop on the resistance , I used a matching network of series inductor ,shunt cap, series inductor .



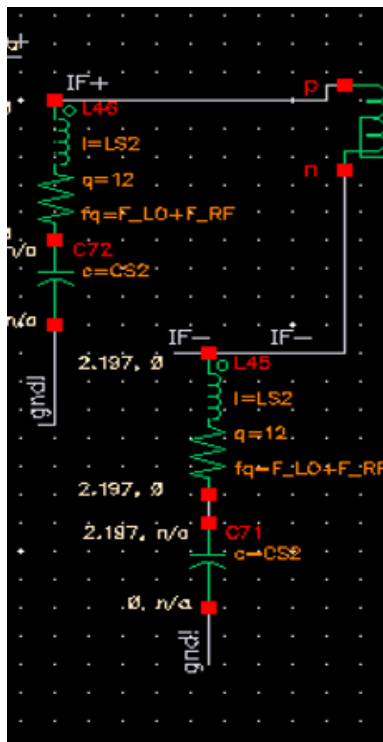
To achieve a S11 under -10 , the following graph was drawn against RF frequency



The S22 was achieved by a resistive load of 50 ohm , choking inductor to increase gain.



It was required to have $IF=RF-LO$, so I used a shunt inductor and shunt capacitor at IF outputs to filter the $RF+LO$.



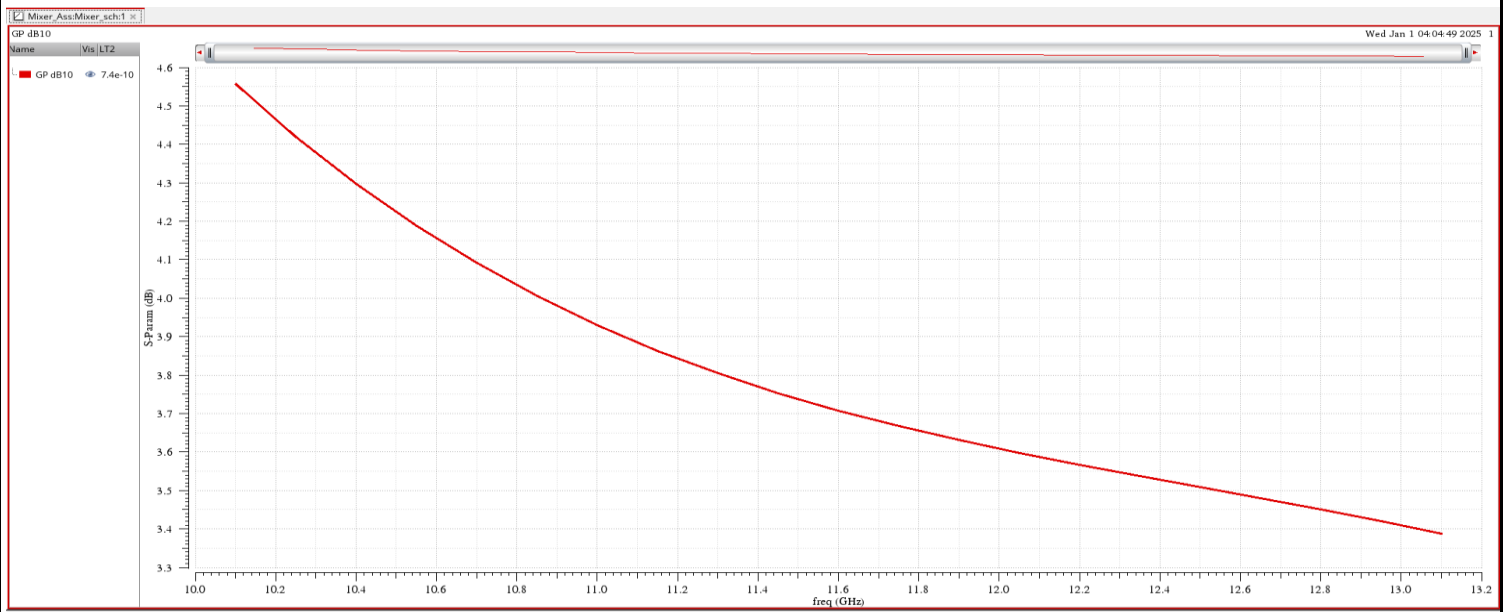
Mixer_Ass:Mixer_sch:1	NFmin	expr	getData("NFmin" ?result "hbsp")	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	H21 dB20	expr	db(hp(2 1 ?result "hbsp"))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	GP dB10	expr	db10(gsp(sp(1 1 ?result "hbsp") sp(1 2 ?result "hbsp") sp(2 1 ?result "hbsp") sp(2 2 ?result "hbsp")))	point	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	Gmax dB10	expr	db10(gmax(sp(1 1 ?result "hbsp") sp(1 2 ?result "hbsp") sp(2 1 ?result "hbsp") sp(2 2 ?result "hbsp")))	point	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	NF	expr	getData("NF" ?result "hbsp")	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	S22 dB20	expr	db(spm("hbsp 2 2))	point	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	S11 dB20	expr	db(spm("hbsp 1 1))	point	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	Gmin	expr	gmin(getData("Gopt" ?result "hbsp") getData("Bopt" ?result "hbsp") zref(1 ?result "hbsp"))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1		expr	xval(value(db10(getData("Fmin" ?result "sp_noise")) 1.3e+10))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1		expr	waveVsWave(?x xval(getData("NFmin" ?result "hbsp")) ?y getData("NFmin" ?result "hbsp"))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1		expr	waveVsWave(?x xval(getData("NFmin" ?result "hbsp")) - 1.2e+10 ?y getData("NFmin" ?result "hbsp"))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	p(/PORT0/PLUS /net019); hb_mt dBmP	expr	dbm(pvi(hb "/net019" 0 "/PORT0/PLUS" 0))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	p(/PORT0/PLUS /net019) F_RF=14G; hb_mt dBmP	expr	dbm(value(pvi(hb "/net019" 0 "/PORT0/PLUS" 0) "F_RF 1.4e+10))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	ZM 3 reOhms	expr	real(zm(3 ?result "hbsp"))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	ZM 2 reOhms	expr	real(zm(2 ?result "hbsp"))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	ZM 1 reOhms	expr	real(zm(1 ?result "hbsp"))	point	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	ZM 3 imOhms	expr	imag(zm(3 ?result "hbsp"))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	ZM 2 imOhms	expr	imag(zm(2 ?result "hbsp"))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	S23 mag	expr	spm("hbsp 2 3)	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	S33 mag	expr	spm("hbsp 3 3)	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	S33 dB20	expr	db(spm("hbsp 3 3))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	ipnCurves	expr	ipnVRICurves(v("/net037" ?result "hb_mt_f") (2 -1) (1 0) ?port i("/PORT2/PLUS" ?result "hb_mt_f") ?epoint -40)	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	Input Referred IP3 Point	expr	ipnVRIC(v("/net037" ?result "hb_mt_f") (2 -1) (1 0) ?port i("/PORT2/PLUS" ?result "hb_mt_f") ?epoint -40)	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	1st Order freq	expr	"cadda(setofx harmonicFreqList(?result \"hb_mt_f\") equal(car(x) \"1 0)))"	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1		signal	/PORT2/PLUS	point	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	compressionCurves	expr	compressionVRICurves(v("/net037" ?result "hb_mt_f") (1 0) ?port i("/PORT2/PLUS" ?result "hb_mt_f") ?epoint -40 ?gcomp 1)	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	Input Referred 1dB Compression Point	expr	compressionVRIC(v("/net037" ?result "hb_mt_f") (1 0) ?port i("/PORT2/PLUS" ?result "hb_mt_f") ?epoint -40 ?gcomp 1)	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	Input Referred IP3 Points	expr	ipnVRIC(v("/net037" ?result "hb_mt_f") (2 -1) (1 0) ?port i("/PORT2/PLUS" ?result "hb_mt_f") ?epoint -20 ?psweep nil)	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	p(/PORT2/PLUS /net037) h=-1,0; hb_mt dBmP	expr	dbm(pvi(hb "/net037" 0 "/PORT2/PLUS" 0) ((1 0)))	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	input-referred	expr	-dbp(CompressionPointCurve("input-referred"))	point	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	Input Referred 1dB Compression Points	expr	compressionVRIC(v("/net037" ?result "hb_mt_f") (0 1) ?port i("/PORT2/PLUS" ?result "hb_mt_f") ?epoint -30 ?gcomp 1)	point	<input type="checkbox"/>	<input type="checkbox"/>	
Mixer_Ass:Mixer_sch:1	p(/PORT2/PLUS /net037) Pin=-30; hb_mt dBmP	expr	dbm(value(pvi(hb "/net037" 0 "/PORT2/PLUS" 0) "Pin -30))	point	<input type="checkbox"/>	<input type="checkbox"/>	

test bench used for runs

1- Plot gain, IIP3, IP1dB, and NF versus RF frequency at IF frequency=100MHz

It was required to have IF = 100MHz so a sweep OF $F_{RF} = 10.1G:1G:13.1G$
With $F_{LO} = F_{RF} - 0.1G$.

1-plot gain



Choosing Analyses -- ADE L (1)

Analysis: ☐ psp ☐ qpss ☐ qpac ☐ qpnoise ☐ qpxf ☐ qpsp ☒ hb ☐ hbnoise ☐ hbac

Harmonic Balance Analysis

Transient-Aided Options

Run transient? ☐ No ☐ Yes

Detect Steady State ☒ Stop Time (tstab) 0

Save Initial Transient Results (saveinit) ☐ no ☐ yes

Dynamic Parameter ☐

Tones ☒ Frequencies ☐ Names

Multi-divider Mode ☐

Number of Tones ☐ 1 ☒ 2 ☐ 3 ☐ 4

Tone 1 F_{LO} Tone 2 F_{RF}

Fundamental Frequency 9 9

Number of Harmonics 3 1

Oversample Factor 3 1

Tone 1 be LO or signal which causes the most nonlinearity.

Freqdivide Ratio for Tone 1 1

Harmonics ☒ Default ☐ Custom

Accuracy Defaults (errpreset) ☒ conservative ☐ moderate ☐ liberal

Oscillator ☐

Sweep ☐

Loadpull ☐

LSSP ☐

Compression ☐

Enabled ☒

Options...

OK Cancel Defaults Apply Help

Choosing Analyses -- ADE L (1)

Analysis: ☐ tran ☐ xf ☐ pz ☐ pac ☐ psp ☐ qpxf ☐ hbnoise ☐ dc ☐ sens ☐ sp ☐ pstb ☐ qpss ☐ qpac ☐ hb ☐ ac ☐ dcmatch ☐ envlp ☐ pnoise ☐ qpnoise ☐ pxf ☐ noise ☐ stb ☐ pss ☐ noise ☐ hbac

Harmonic Balance SP Analysis

Sweeptype ☒ default ☐ custom Sweep is Relative to Ports

Frequency Sweep Range(Hz)

Start-Stop ☒ Start 1 Stop 3G

Sweep Type ☒ Linear ☐ Step Size ☐ Number of Steps 20

Add Specific Points ☐

Select Ports ☒

Port#	Name	Harm.	Frequency
1	/PORT0	0 1	10G - 13G
2	/PORT2	-1 1	2 - 3G

Select Port Choose Harmonic Add Change Delete

Do Noise ☒ yes ☐ no Maximum Sideband

Enabled ☒

Options...

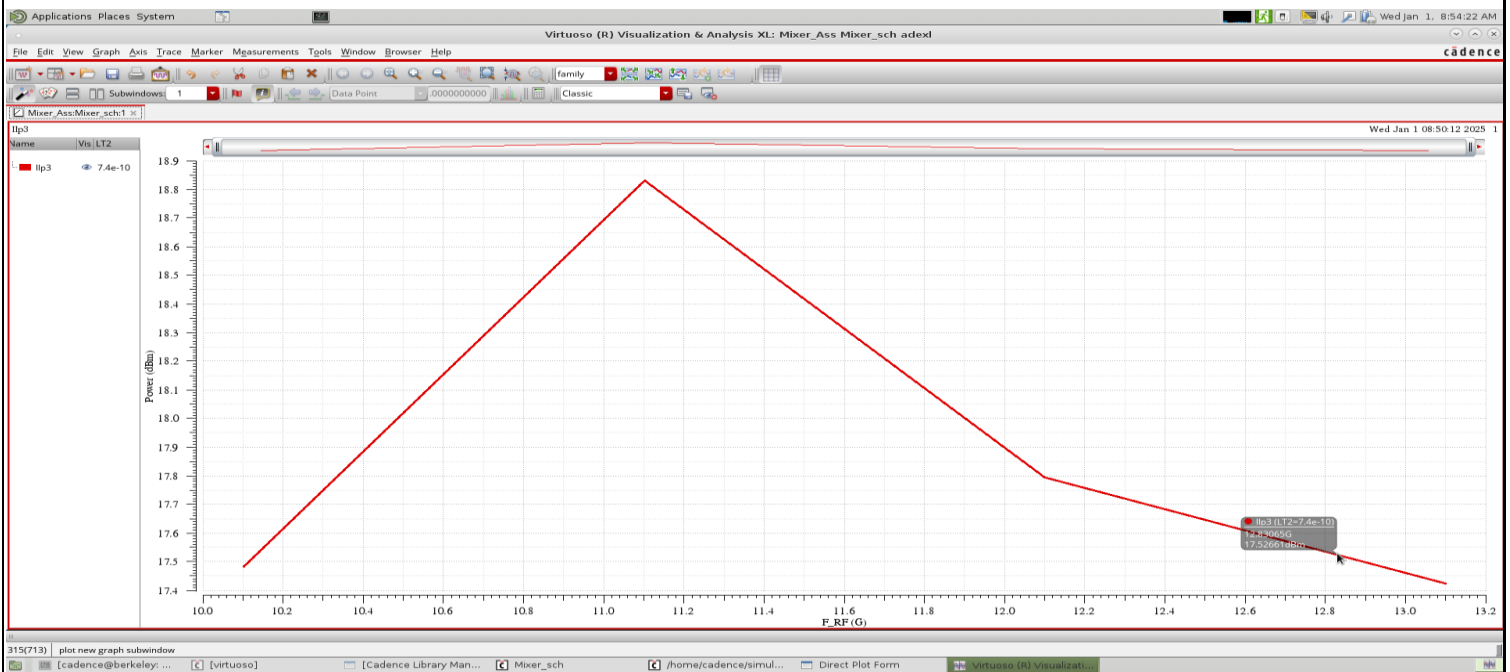
OK Cancel Defaults Apply Help

Configuration used for test noise figure and gain.

2- plot NF



3- plot IIP3



Choosing Analyses -- ADE L (1)

Multi-divider Mode ☐

Number of Tones ☐ 1 ☐ 2 ☒ 3 ☐ 4

	Tone 1	Tone 2	Tone 3
Fundamental Frequency	F_LO	F_RF	F_RFtwo
Number of Harmonics	9	9	9
Oversample Factor	3	1	1

Tone 1 be LO or signal which causes the most nonlinearity.

Freqdivide Ratio for Tone 1

Harmonics

Accuracy Defaults (errpreset)

☒ conservative ☐ moderate ☐ liberal

Oscillator ☐

Sweep ☒

Variable

Frequency Variable? ☐ no ☒ yes

Variable Name

Sweep Range

☒ Start-Stop Start Stop

☐ Center-Span

Sweep Type

☒ Linear ☐ Step Size

☐ Logarithmic ☐ Number of Steps

Add Specific Points ☐

Loadpull ☐

LSSP ☐

Compression ☐

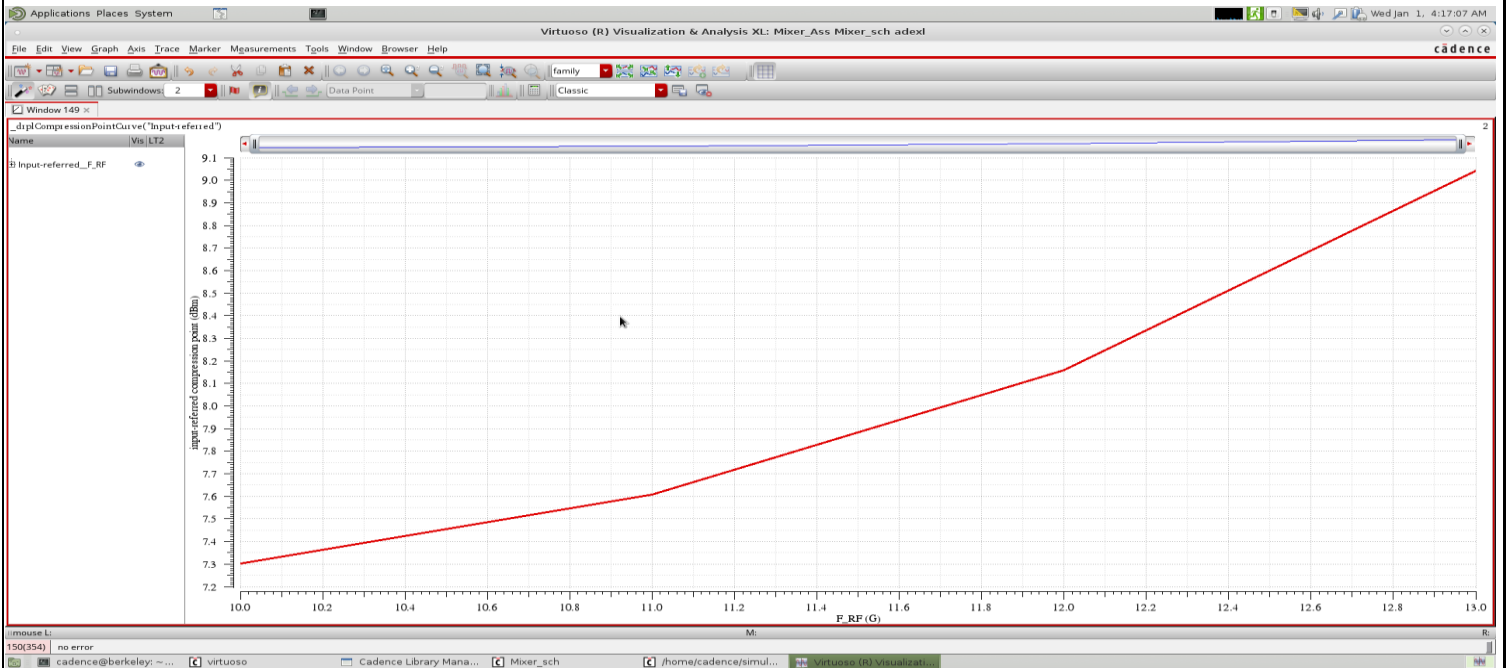
Enabled ☒

3 tone test was used to get IIP3 where

$$F_{LO} = F_{RF} - 0.1G$$

$$F_{RFtwo} = F_{RF} + 0.1G$$

4-plot P1dB



Choosing Analyses -- ADE L (1)

Number of Tones: ☐ 1 ☒ 2 ☐ 3 ☐ 4

Fundamental Frequency: Tone 1: F_LO, Tone 2: F_RF

Number of Harmonics: 9, 9

Oversample Factor: 3, 1

Tone 1 be LO or signal which causes the most nonlinearity.

Freqdivide Ratio for Tone 1: 1

Harmonics: Default

Accuracy Defaults (errpreset): ☒ conservative ☐ moderate ☐ liberal

Oscillator: ☐

Sweep: ☐

Loadpull: ☐

LSSP: ☐

Compression: ☒

Rapid Mode: ☐

Gain Definition: Power

Gain Reference: Small-Signal Gain

Compression Levels (dB): 1

Output/Load Harmonic: -1 1

Frequency	Tone1	Tone2
0	0	0
1	-1	1
2	-2	2
3	-3	3
4	-4	4

Source: /PORT0

Load: /PORT2

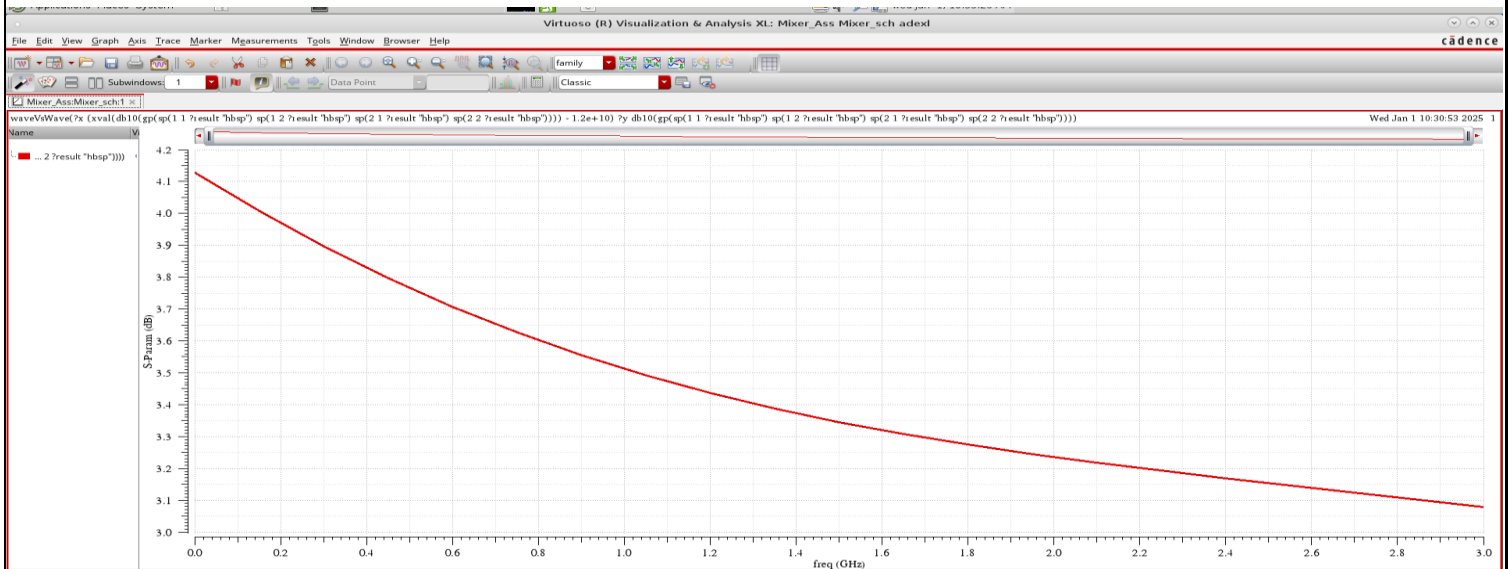
Enabled: ☒

OK Cancel Defaults Apply Help

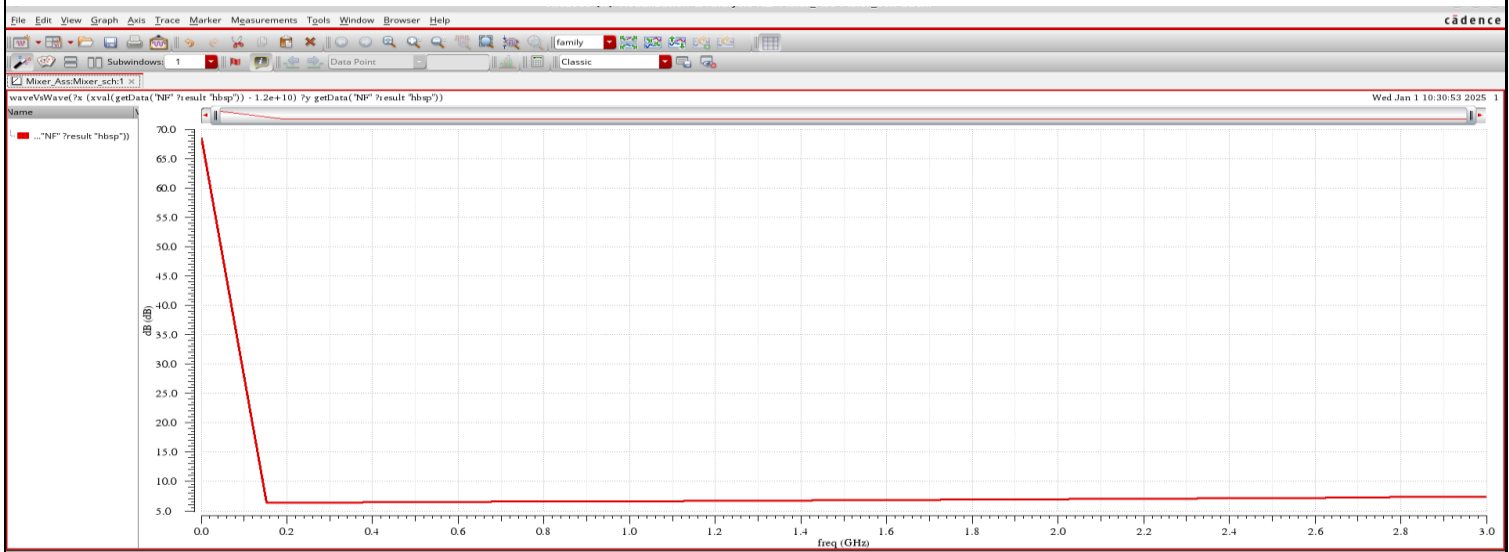
2- Plot gain, IIP3, IP1dB, and NF versus IF frequency at LO frequency = 12GHz

F_LO=12GHZ & F_RF = 12G:1G:15G

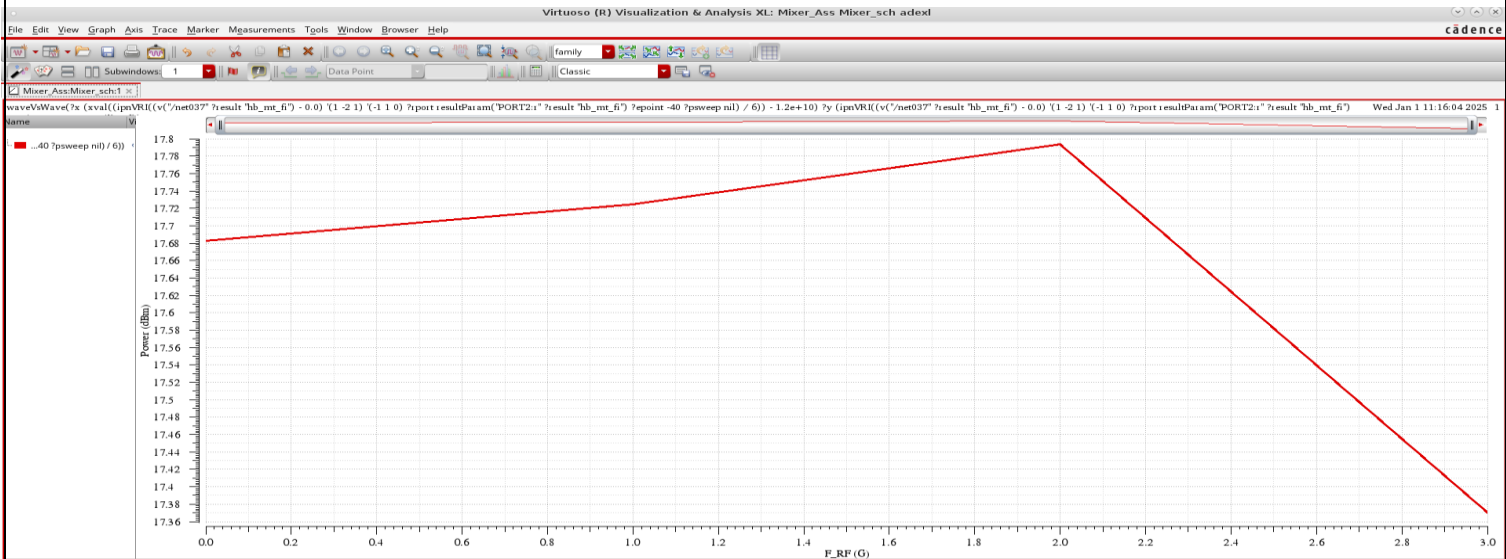
1-plot gain



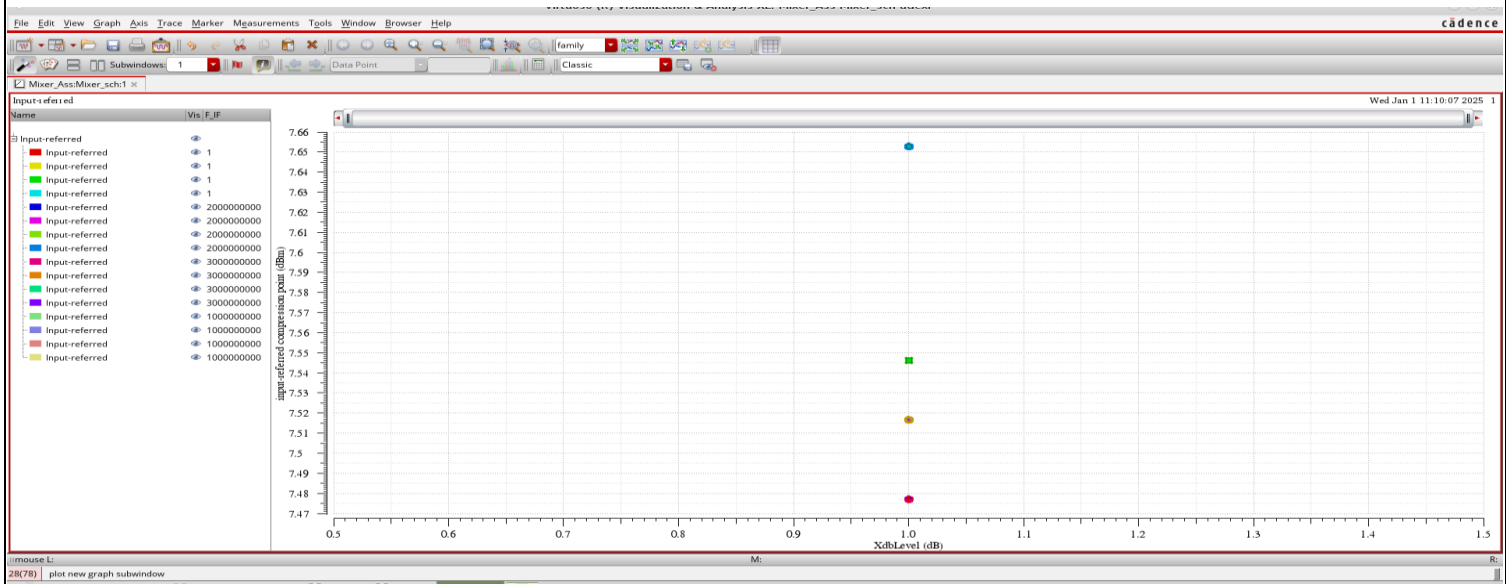
2- plot NF



3- plot IIP3

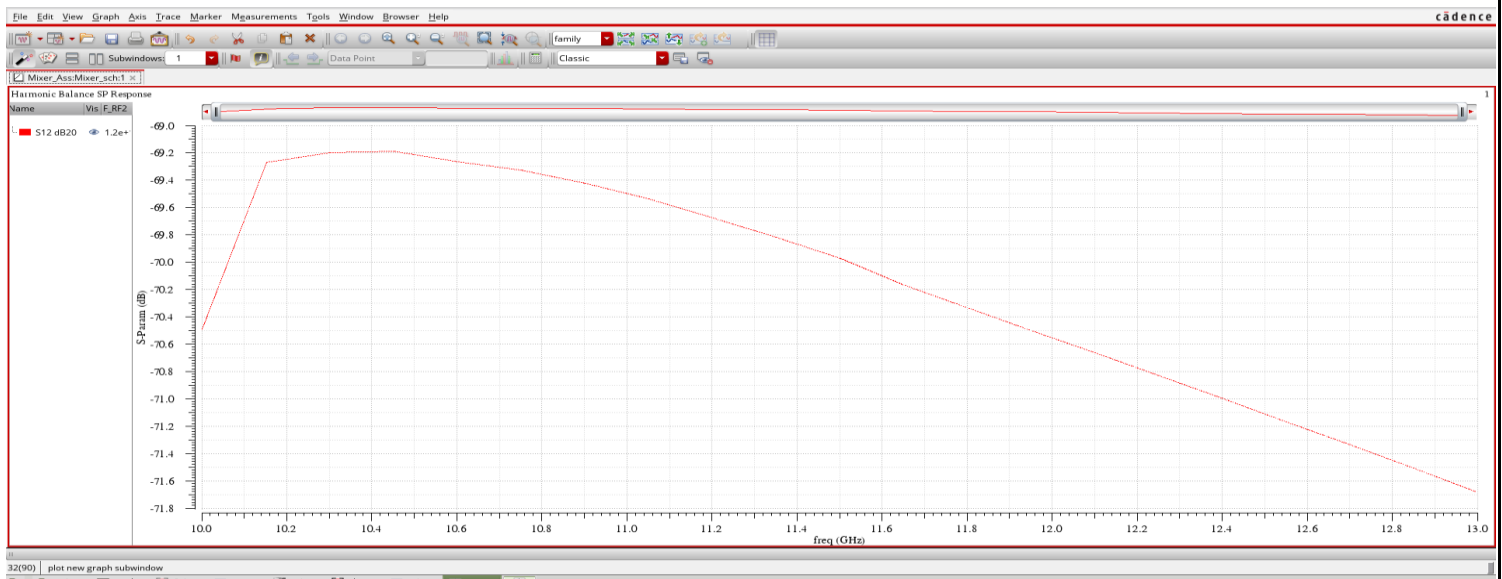


4-plot P1dB



3- Plot LO to RF isolation and LO to IF isolation versus LO frequency, during this simulation assume LO transistor sizes are different by 1% (i.e. increase width of one side of LO transistor by 1%)

LO to RF isolation :



Choosing Analyses -- ADE L (1)

Analysis:

- ☐ tran
- ☐ dc
- ☐ ac
- ☐ noise
- ☐ xf
- ☐ sens
- ☐ dcmatch
- ☐ stb
- ☐ pz
- ☐ sp
- ☐ envlp
- ☐ pss
- ☐ pac
- ☐ pstb
- ☐ pnoise
- ☐ pxf
- ☐ psp
- ☐ qpss
- ☐ qpac
- ☐ qpnoise
- ☐ qpxf
- ☐ qpss
- ☐ hb
- ☐ hbac
- ☐ hbnoise
- ☒ hbsp

Harmonic Balance SP Analysis

Sweep type: default Sweep is Relative to Ports

Frequency Sweep Range(Hz)

Start-Stop: Start 1 Stop 3G

Sweep Type: Linear Step Size 20 Number of Steps

Add Specific Points: ☐

Select Ports: ☒

Port#	Name	Harm.	Frequency
1	/PORT1	0	100 - 13G
2	/PORT0	0	100 - 13G
3	/PORT2	-1	2 - 3G

1 /PORT1 1 0 100 - 1

Select Port Choose Harmonic Add Change Delete

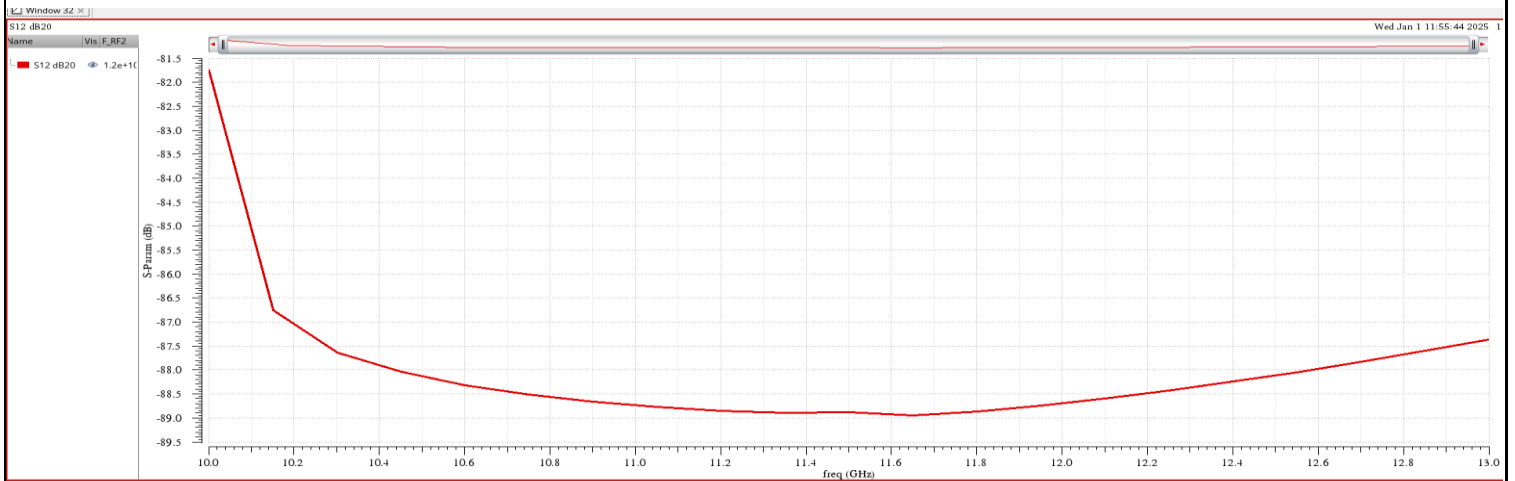
Do Noise: ☒ yes Maximum Sideband ☐ no

Enabled: ☒

Options...

OK Cancel Defaults Apply Help

LO to IF isolation :



Choosing Analyses -- ADE L (1)

Analysis

☐ tran ☐ dc ☐ ac ☐ noise

☐ xf ☐ sens ☐ dcmatch ☐ stb

☐ pz ☐ sp ☐ envlp ☐ pss

☐ pac ☐ pstb ☐ pnoise ☐ pxf

☐ psp ☐ qpss ☐ qpac ☐ qpnoise

☐ qpxf ☐ qpdp ☐ hb ☐ hbac

☐ hbnoise ☒ hbap

Harmonic Balance SP Analysis

Sweeptype: default Sweep is Relative to Ports

Frequency Sweep Range(Hz)

Start-Stop Start 1 Stop 36

Sweep Type

Linear ☐ Step Size 20

☒ Number of Steps

Add Specific Points ☐

Select Ports ☒

Port#	Name	Harm.	Frequency
1	/PORT1	1 0	10G - 13G
2	/PORT2	-1 1	2 - 3G
3	/PORT0	0 1	10G - 13G

2 /PORT2 -1 1 2 - 3G

Select Port Choose Harmonic Add Change Delete

Do Noise

☒ yes Maximum Sideband

☐ no

Enabled ☒ Options...

OK Cancel Defaults Apply Help

	Spec	achieved
Conversion Gain	3	>3
NF	15db	<10
IIP3	17dbm	17-18
LO to RF Isolation	30db	-60
LO to IF Isolation	40db	-80
IP1dB	7dbm	>7