Cascade analysis using SystemVue

Varun Mannam

***Abstract*—Designed the receiver front-end part using SystemVue and generated the compression curve for relation between Input and Output Power. Results are provided here for different performance metrics namely noise Figure, OIP3, SFDR and analyzed the behaviour of each curve for the given block diagram.**

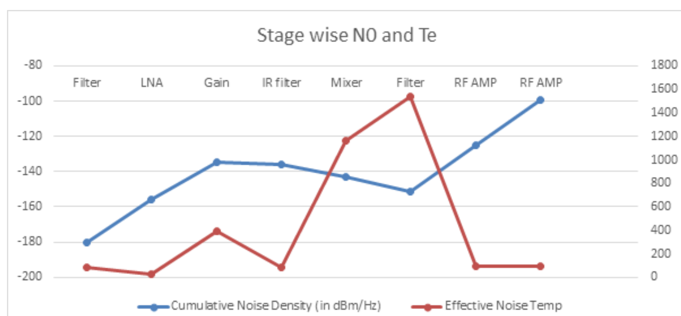
I. PROBLEM2

These are the results from spread sheet: (these are different from HW2).

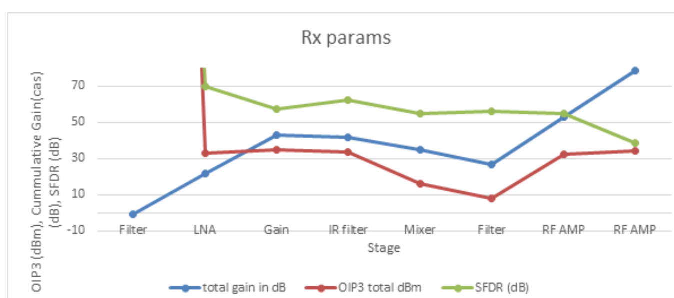
1) Filter: BPF
   a) IL=1.13dB (gain= -1.13 dB)
   b) NF=1.13dB
   c) BW=250M (but it is 100MHz from spec sheet) -> derived the PSD throughout blocks and added CHbw at the end which is 30M.
2) Filter: BPF
   a) NF=0.35 (at 2.45GHz)
   b) Gain=23dB
   c) OIP3 =33dBm
   d) BW= 5GHz
3) Gain block
   a) Gain = 21dB 1dB = 16dBm
   b) OIP3=35dBm
   c) NF=3.7dB
4) IRFilter: BPF
   a) IL=1.13dB (gain= -1.13 dB)
   b) NF=1.13dB
   c) BW=45M.
5) Mixer
   a) Conversion gain = -7dB
   b) IIP3 = 23dBm
   c) IIP1dB = 17dBm
   d) LO power = +2.4dBm
   e) BW=900MHz
6) Channel select Filter:
   a) IF Centre frequency= 168.5MHz
   b) IL=8dB
   c) 1dB BW=26.4MHz -> 3dB BW = 30MHzIL=1.13dB (gain= -1.13 dB)
7) IF amplifier
   a) NF=1.25dB
   b) Gain = 26dB (need to see gain at IF freq)
   c) OIP3=34dBm
   d) P1dB = 19dB
   e) BW= 1GHz
8) LO Frequency 2.268.5GHz, Power 6dBm.
9) LO attenuation: Attenuation of 19dB
10) LO gain
    a) NF=3.7dB
    b) Gain=15.4dB

This is the result of cascade analysis using Excel.
Used the Incoherent OIP3 values:
Formulas:
OIP3= IIP3*Gstage
1/OIP3 tot= 1/(GPresent*OIP3prv) + (1/OIP3 current); for coherent

Stage	Cumulative Noise Density (in dBm/Hz)	Effective Noise T
Filter	-180.377044	86.18198859
LNA	-156.0214605	24.33880507
Gain	-134.9289804	389.8263564
IR filter	-136.0588197	86.18198859
Mixer	-143.0560068	1163.442978
Filter	-151.0373949	1539.776299
RF AMP	-125.0300403	96.72121533
RF AMP	-99.03002188	96.72121533



Receiver parameters like Spurious free dynamic range (SFDR), OIP3 and cascaded gain are calculated.



Gain overall? Cascaded gain= 78.74 dB.
Gain is not enough when the input signal is at -100dBm,

since the signal after gain will be -20dBm whereas Noise with CHbw=20MHz is -26dBm. So At IF/BB we donâĂŹt have minimum SNR of 10dB which is the typical value to demodulate the signal.
Signal: -100 + 80 -> -20dBm Noise: -99dBm + 10*log(20M) = -26dBm SNR is 6dB which is less than typical value of 10dBm. So gain is not enough at -100dBm.
Noise Figure NF is 1.5154 dB.
It is pretty low compared to all other models proposed in this report, but we can increase the gain by adding more ampâĂŹs to RF frontend after LNA and with good LNA with LOW NF value. If we want more dynamic range of ADC, we can use IF amplifiers, so that weâĂŹve the signal above minimum detectable range.
Noise: Since we have multiple gain stages, Noise PSD at the end of system is -99dBm/Hz. Based on channel BW, noise power is computed at IF stage.
Linearity: Use the RF component with high linear gain. Ex. Filters/passive components âĂŸve highest linearity with in band. Here OIP3 is 34dBm.

A. *Good and bad parts of the design*

1) Given design doesnâĂŹt contain the IR block, we added in our simulation results.
2) Attenuator and Gain block in LO part are reversed for best performance.
3) IF band : IF is 168.5MHz which is far away from Image frequencies.
4) No of Gain stages: Gain stages is not sufficient, since at -100dBm power the SNR is less than 10dB

B. *Performance improvements*

1) To increase SFDR: By adding additional Gain block at IF stage, we got overall gain more, but SFDR decreases by this step.
2) Decrease NF: LNA with more gain will reduce the overall NF value. But it is more costly than low NF LNA with less gain.

II. Problem3

Cascade analysis using Systemvue is performed and plots are obtained from that are provided here.

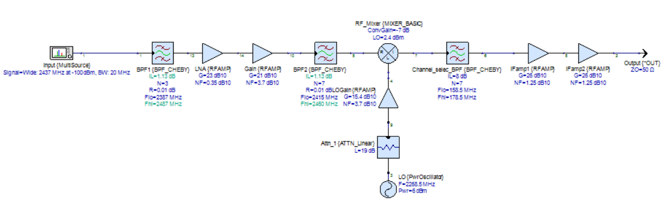


Fig. 1. Cascade Design of Receiver (dB)

Main parameters of the receiver design is:

1) Cascaded Noise Figure
2) Cascaded Gain
3) OIP3
4) SFDR
5) Op1dB

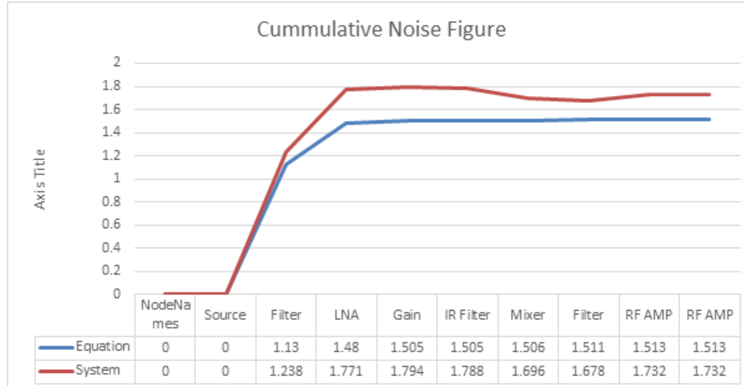


Fig. 2. Cascaded Noise Figure (dB)

For Cascaded gain:

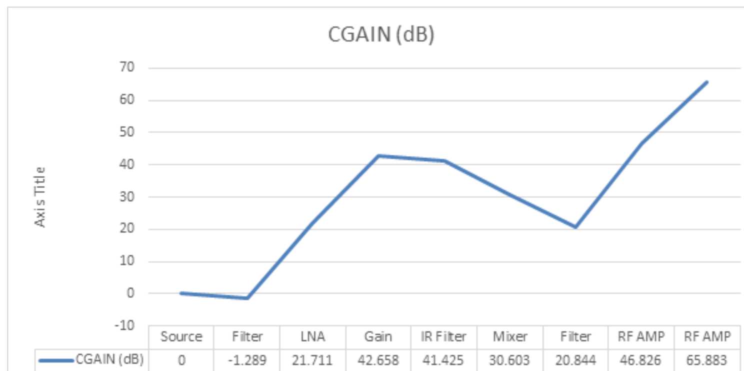


Fig. 3. Cascaded Gain (dB)

For Output 1dB power:

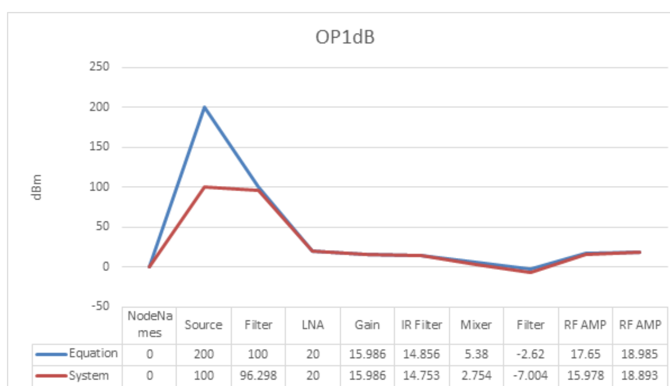


Fig. 4. Output 1dB (dBm)

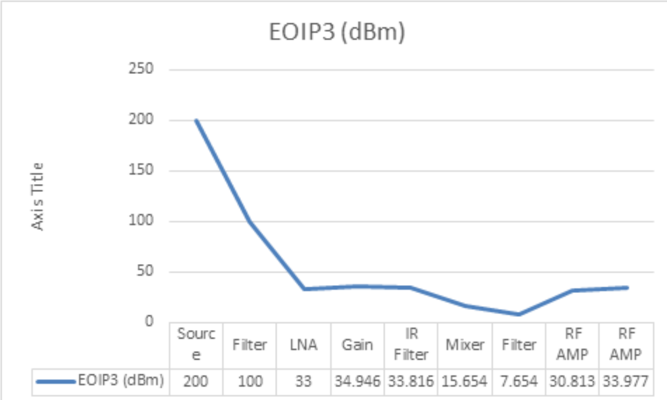


Fig. 5. Output IP3 (dBm)

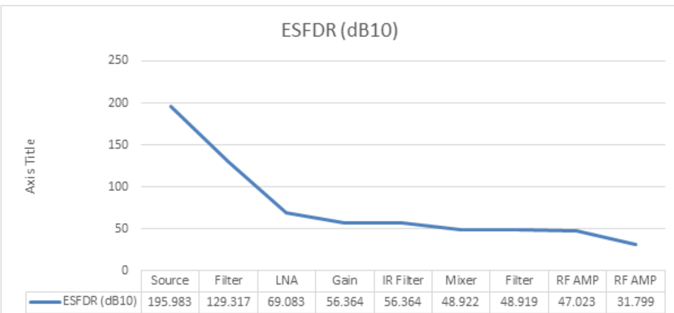


Fig. 6. SFDR (dB)

A. Part b

Did the experiments as suggested in the lab paper.

1) I have Some questions in Mixer operations.
2) Last stage of RF amp has some compression.

B. Part c

This is the compression curve using Systemvue.

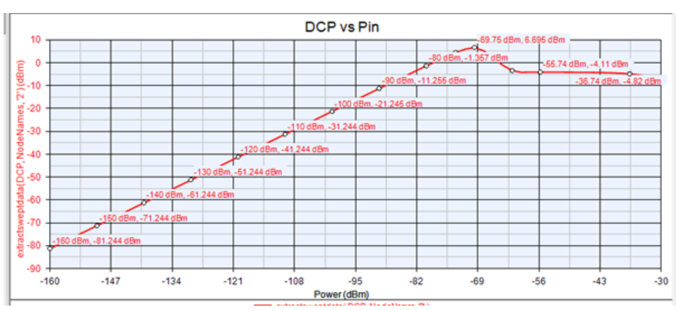


Fig. 7. Compression Curve (Pin vs Pout) (dBm)

C. Part d

Spectrum is plotted at various nodes and system performance is observed at different nodes.

Her is the spectrum at input and output of the receiver using Systemvue.

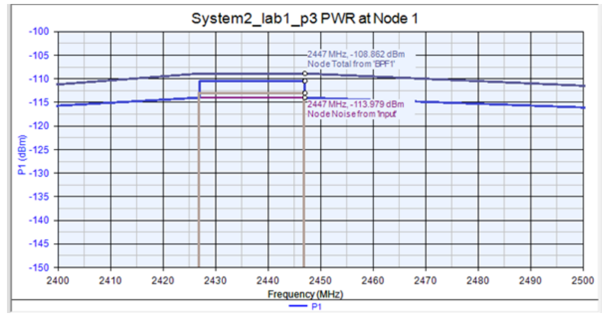


Fig. 8. Input Spectrum (dBm)

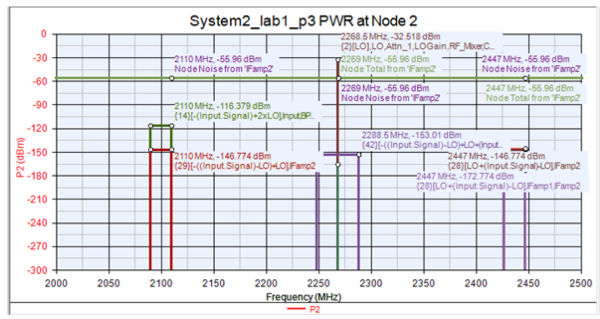


Fig. 9. Output Spectrum (dBm)

III. Results Discussion

These are the collective results for Problem3.

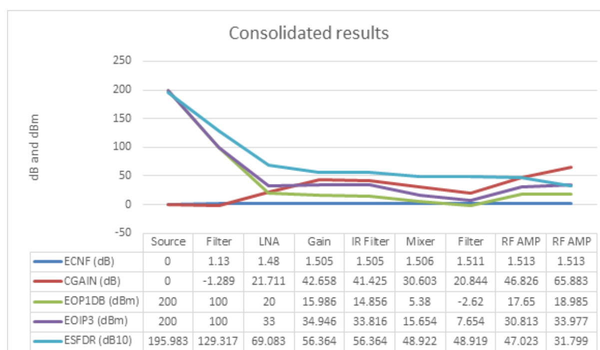


Fig. 10. Cascade Analysis Parameters

IV. Conclusion and Future Work

We have executed the cascade analysis using SystemVue and compared with the theoretical values.
Following are the directions for future work:

1) Mixer: Understand the Mixer block and its parameters.
2) Add the base band section to present analysis to know complete receiver chain performance.

References