Cairo University **Faculty of Engineering**

Advanced Topics in Electronics-1

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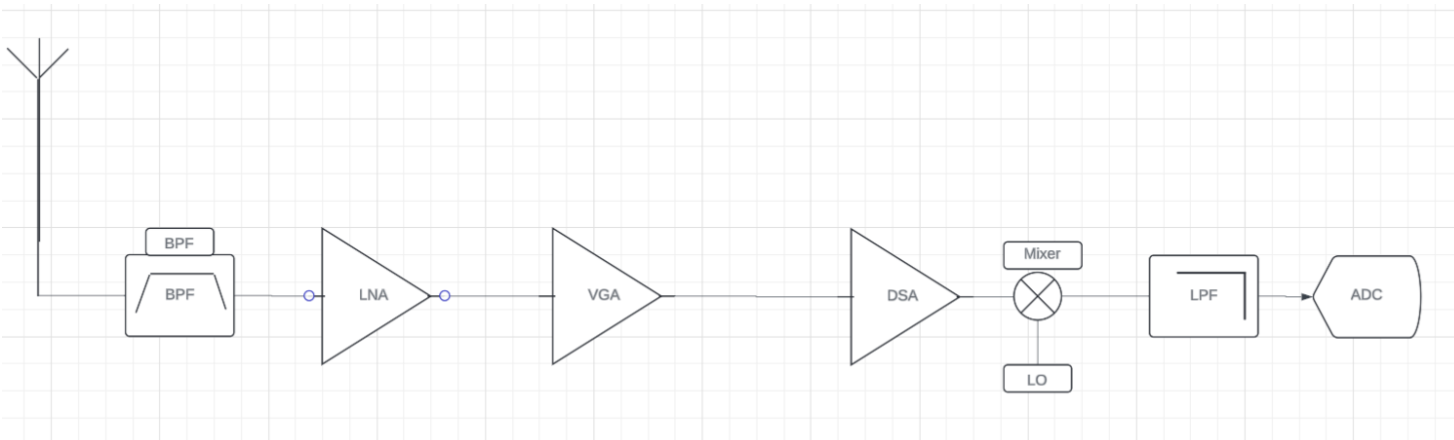
- **Show the block diagram of your proposed receiver**

All the indicated values are referenced from ADI website , TI website , lecture and Papers. the block proposed consists of BPF , LNA , VGA ,DSA, mixer, LPF



I also used amp/attenuator topologies as the NF needed to achieve the needed SNR at sensitivity was very low and the OIP_3 needed was achieved without attenuator/amp topologies.

it has multiple disadvantages like LO leakage and dc offset.

The BPF (passive) is used at the beginning to filter out of band blockers, and it was used in front of the LNA so the out of band blockers won't reach the LNA and cause desensitization to the signal and cause the gain to drop to zero, but it has a disadvantage that it causes the NF to drop because of the loss that is add up across the chain.

A VGA is used to achieve a gain up to $50\ dB$ to have $P_{out} = -20\ dBm$ at $P_{in} = -70\ dBm$ programmable from $5dB$ to $37\ dB$ with a step $1\ dB$.

A DSA is used to attenuate the Gain in case of gain needed $=\ 0\ dB \rightarrow 5\ dB$ for $P_{in} = -20 \rightarrow 15\ dBm$ ➔ programmable with a gain step of $2\ dB$ with a range ($0\ dB$➔$-46\ dB$) with LPF (active filter) to filter the in-channel blockers.

- **<u>Indicate all gain/noise/linearity specs for the receiver blocks</u>**

<u>The gain/noise/linearity specs for $P_{in} = -102\ dBm$ spec for sensitivity, notice that $NF = 2\ dB$ which is required for a SNR of $0\ dB$. (We used VVA as we did not find a DSA on Qorvo)</u>

Component Name	Filter	LNA	VGA	VVA	Mixer
Gain (dB)	-1	15	37	0	11
NF (dB)	1	0.75	5	10	5
P1dB (dBm)	20	6	25	13	18
IP3 (dBm)	30	20	42	46	28

System Description	Stage 6
Component Name	Filter
Gain (dB)	10
NF (dB)	10
P1dB (dBm)	20
IP3 (dBm)	30

OUTPUTS

Parameter	Output
Gain (dB)	72.00
NF (dB)	1.99
P1dB (dBm)	19.21
IP3 (dBm)	29.36

<u>The gain/noise/linearity specs for $P_{in} = -70\ dBm$</u>

Component Name	Filter	LNA	VGA	VVA	Mixer
Gain (dB)	-1	15	15	0	11
NF (dB)	1	0.75	11	10	5
P1dB (dBm)	20	6	20	13	18
IP3 (dBm)	30	20	33	46	28

System Description	Stage 6
Component Name	Filter
Gain (dB)	10
NF (dB)	10
P1dB (dBm)	20
IP3 (dBm)	30

OUTPUTS

Parameter	Output
Gain (dB)	50.00
NF (dB)	2.95
P1dB (dBm)	19.16
IP3 (dBm)	[illegible]

The gain/noise/linearity specs for $P_{in} = -60\ dBm$

[redacted]	Filter	LNA	VGA	VVA	Mixer
Gain (dB)	-1	15	5	0	11
NF (dB)	1	0.75	18	10	5
P1dB (dBm)	20	6	20	13	18
IP3 (dBm)	30	20	32	46	28

System Description	Stage 6
Component Name	Filter
Gain (dB)	10
NF (dB)	10
P1dB (dBm)	20
IP3 (dBm)	30

OUTPUTS

Parameter	Output
Gain (dB)	40.00
NF (dB)	6.15
P1dB (dBm)	18.96
IP3 (dBm)	29.25

The gain/noise/linearity specs for $P_{in} = -50\ dBm$

[redacted]	Filter	LNA	VGA	VVA	Mixer
Gain (dB)	-1	15	5	-10	11
NF (dB)	1	0.75	18	10	5
P1dB (dBm)	20	6	20	3	18
IP3 (dBm)	30	20	32	36	28

System Description	Stage 6
Component Name	Filter
Gain (dB)	10
NF (dB)	10
P1dB (dBm)	20
IP3 (dBm)	30

OUTPUTS

Parameter	Output
Gain (dB)	30.00
NF (dB)	6.48
P1dB (dBm)	16.44
IP3 (dBm)	28.35

The gain/noise/linearity specs for $P_{in} = -40\ dBm$

Component Name	Filter	LNA	VGA	VVA	Mixer
Gain (dB)	-1	15	5	-20	11
NF (dB)	1	0.75	18	10	5
P1dB (dBm)	20	6	20	-7	18
IP3 (dBm)	30	20	32	26	28

System Description	Stage 6
Component Name	Filter
Gain (dB)	10
NF (dB)	10
P1dB (dBm)	20
IP3 (dBm)	30

OUTPUTS

Parameter	Output
Gain (dB)	20.00
NF (dB)	8.87
P1dB (dBm)	9.12
IP3 (dBm)	23.77

The gain/noise/linearity specs for $P_{in} = -30\ dBm$

Component Name	Filter	LNA	VGA	VVA	Mixer
Gain (dB)	-1	15	5	-30	11
NF (dB)	1	0.75	18	10	5
P1dB (dBm)	20	6	20	-17	18
IP3 (dBm)	30	20	32	16	28

System Description	Stage 6
Component Name	Filter
Gain (dB)	10
NF (dB)	10
P1dB (dBm)	20
IP3 (dBm)	30

OUTPUTS

Parameter	Output
Gain (dB)	10.00
NF (dB)	16.05
P1dB (dBm)	-0.50
IP3 (dBm)	15.01

The gain/noise/linearity specs for $P_{in} = -20\ dBm$

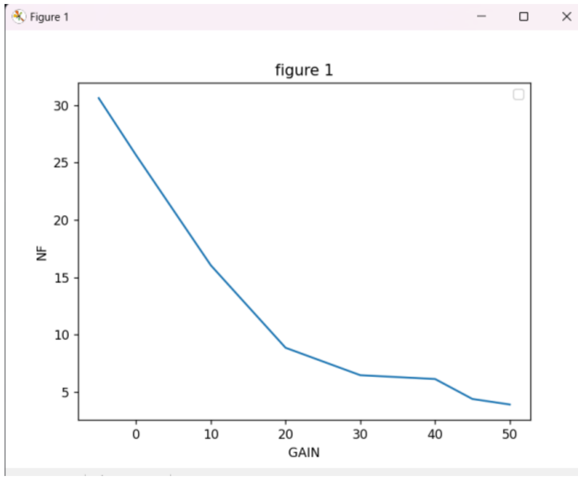
Component Name	Filter	LNA	VGA	VVA	Mixer
Gain (dB)	-1	15	5	-40	11
NF (dB)	1	0.75	18	10	5
P1dB (dBm)	20	6	20	-17	18
IP3 (dBm)	30	20	32	16	28

System Description	Stage 6
Component Name	Filter
Gain (dB)	10
NF (dB)	10
P1dB (dBm)	20
IP3 (dBm)	30

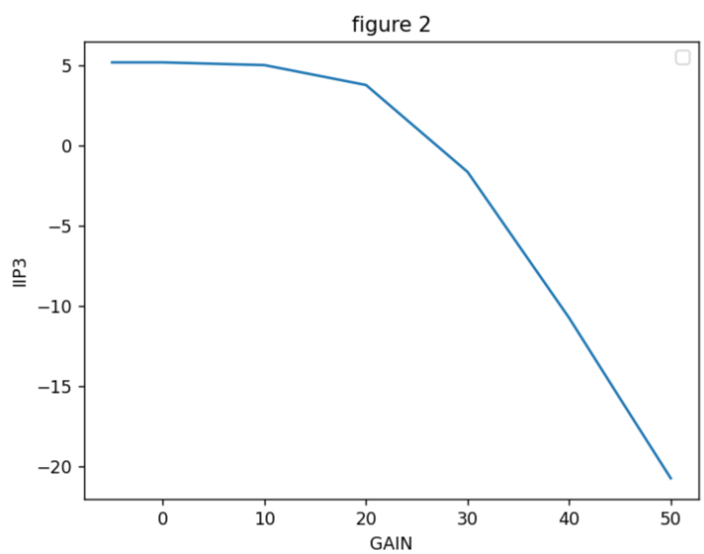
OUTPUTS

Parameter	Output
Gain (dB)	0.00
NF (dB)	25.64
P1dB (dBm)	-8.76
IP3 (dBm)	5.18

- **Provide NF and IIP_3 plots versus gain**



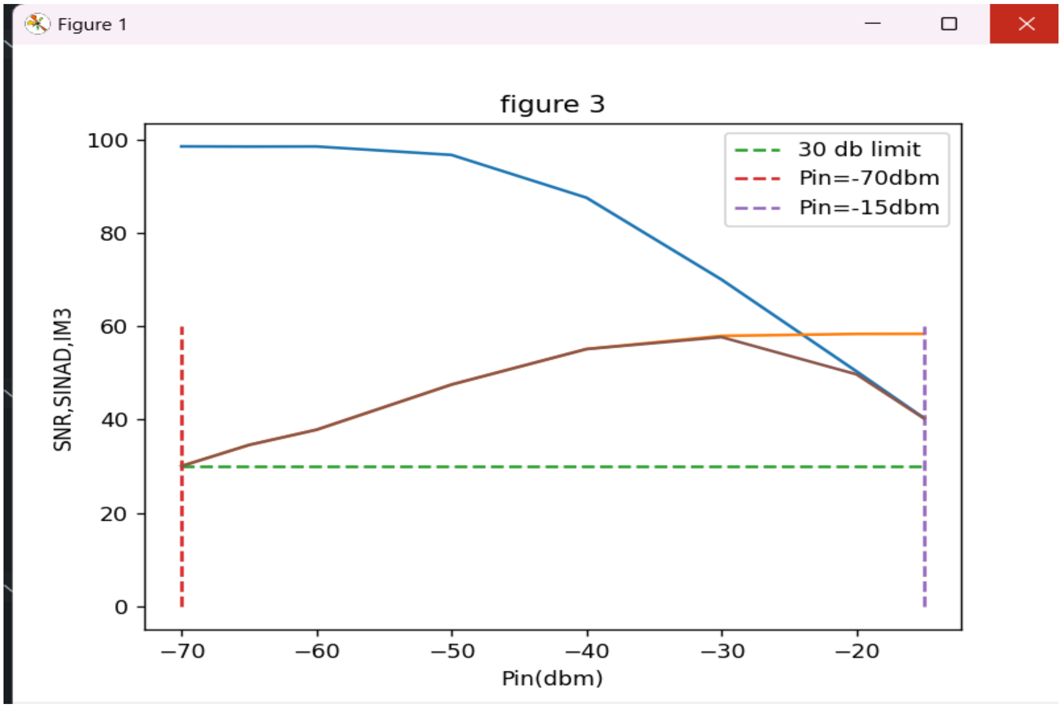
The noise figure began to saturate as the gain become higher because noise figure law (Frizz's law) $= NF_1 + \frac{NF_2}{AP_1} + \cdots + \frac{NF_n}{AP_1 \ldots AP_n - 1}$ as gain increase noise figure decrease and it reaches a certain point and begin to saturate.



$$\frac{1}{A_{IP3}^2} \cong \frac{1}{A_{IP3,1}^2} + \frac{\alpha_1^2}{A_{IP3,1}^2} + \frac{\alpha_1^2 \beta_1^2}{A_{IP3,1}^2} + \cdots$$

From the previous equation, IIP_3 will get affected by the gain of the following blocks, and the non-linearity in the following blocks increases as the gain increases.

- **Show the SNR, IM_3, & $SNDR$ curves for the receiver versus P_{in}**



The specs for the $SNDR > 30\ dB$ is achieved at $P_{in} = -70\ \text{dBm} \rightarrow -15\ \text{dBm}$

➔ which is shown the values.

$SNDR$ Values:

```
[30.069999379439277, 34.58999822669179, 37.84999626075326, 47.519947545628405, 55.12750735934951, 57.688399464061916, 49.7210
7965856621, 40.29217517892137]
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$P_{in} = -102\ dBm$, $Gain = 72\ dB$, & $NF = 2\ dB$, required SNR is achieved

SNR value:

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SNR is level at sensitivity is equal to 0.08000000000000007 db
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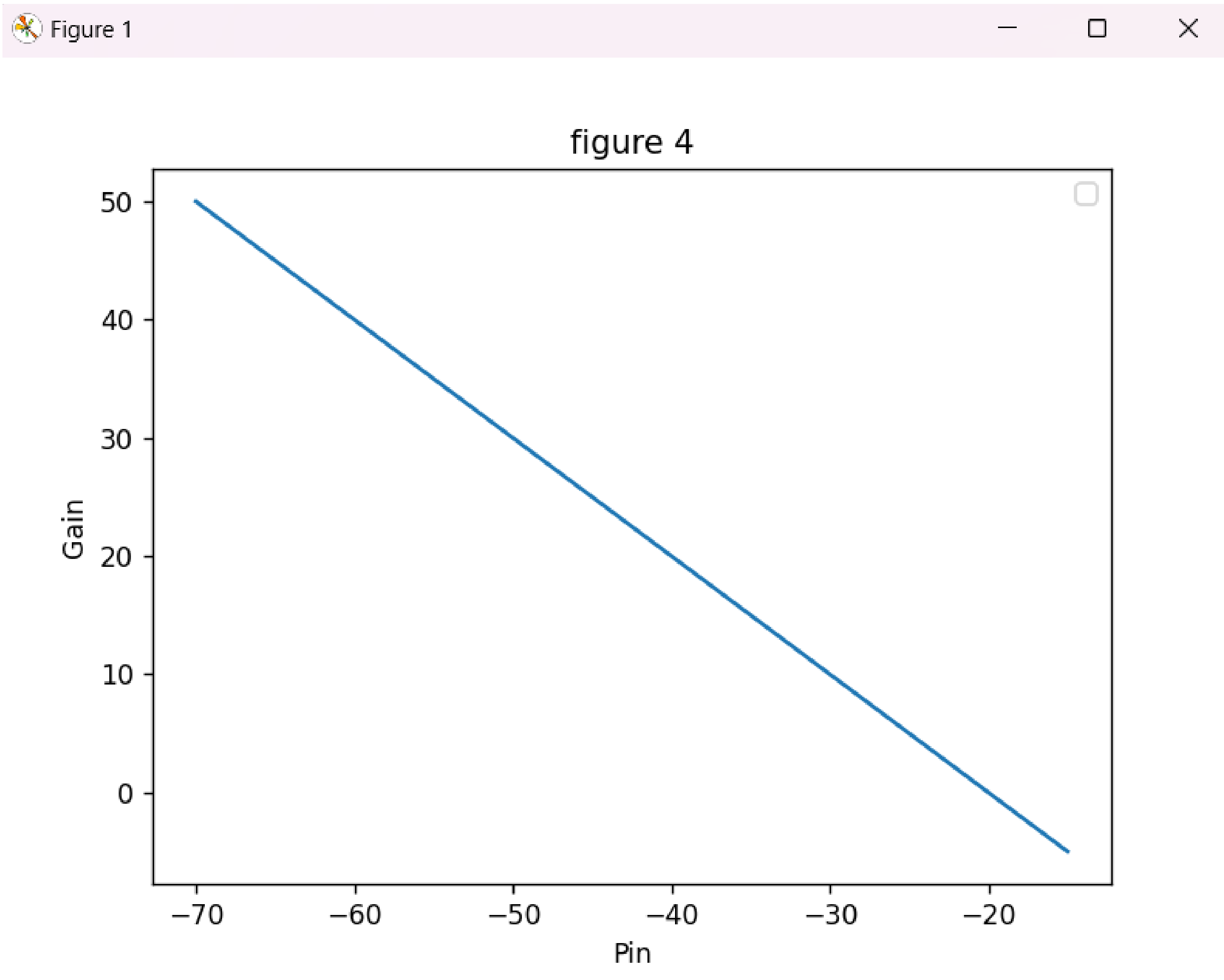
- **Plot the gain versus Pin that achieves the above results**



The gain policies used is from $-5\ dB \rightarrow 50\ dB$ when P_{in} increases by $10\ dBm$ the gain decrease $10\ dB$ to have a P_{out} in this range of -20 dBm.

The code used to plot the graphs was done by a python code.
The link:
https://drive.google.com/file/d/13V8WIza1XixoOcS24BomWlRg7ZyLNQVP/view?usp=sharing