

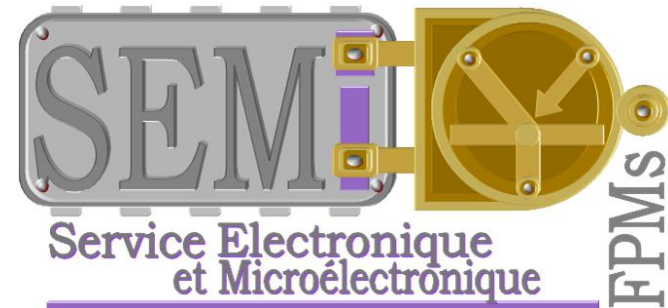


POLYTECH.MONS

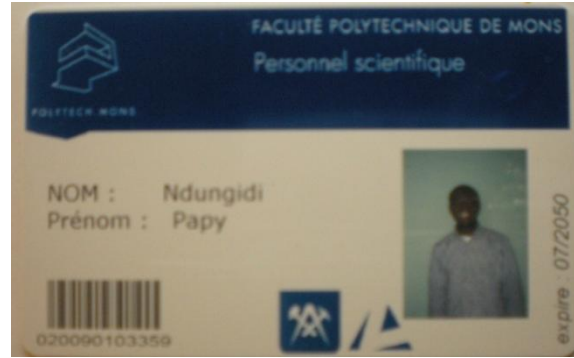
# Modeling and design of heterogeneous systems

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**EuroDocInfo 09**







# Introduction

- ❑ The user asks for devices containing the most possible functionalities, consuming less possible energy and at very low cost.
- ❑ The industry reflect these demands on engineers.
- ❑ The complexity of these devices requires collaboration between heterogeneous teams and work environments.

# Introduction

- ❑ Uses modeling.
  - Through the modeling of its wireless communication system, the Kysoh company increased the range of the transmitter - receiver of Tux of 75%.



- ❑ To reinforce the Top- Down methodology of design by allowing parallelism.
- ❑ Provide **tools** that facilitate the work of engineers.

# Outline

- Introduction
- **Presentation of our toolbox**
- Examples of use of the toolbox
- Summary, Future work

# Presentation of our toolbox

- ❑ Designed in Simulink/Matlab, the blockset covers the following areas:
  - RF
  - Baseband
  - Analog
  - Digital.
- ❑ It includes configurable blocks, modeling the components of RF communication chain with major imperfections (noise and nonlinearity) to generate a specification.

# Presentation of our toolbox

- ❑ This toolbox () models the physical layer of the majority of Wireless Personal Area Network (WPAN).
- ❑ Moreover, the blockset contains tools making possible to check that the parameters of blocks respect a given standard.



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# Examples of use of the toolbox

## IEEE 802.15.4

Low power consumption, low cost and low data rate.

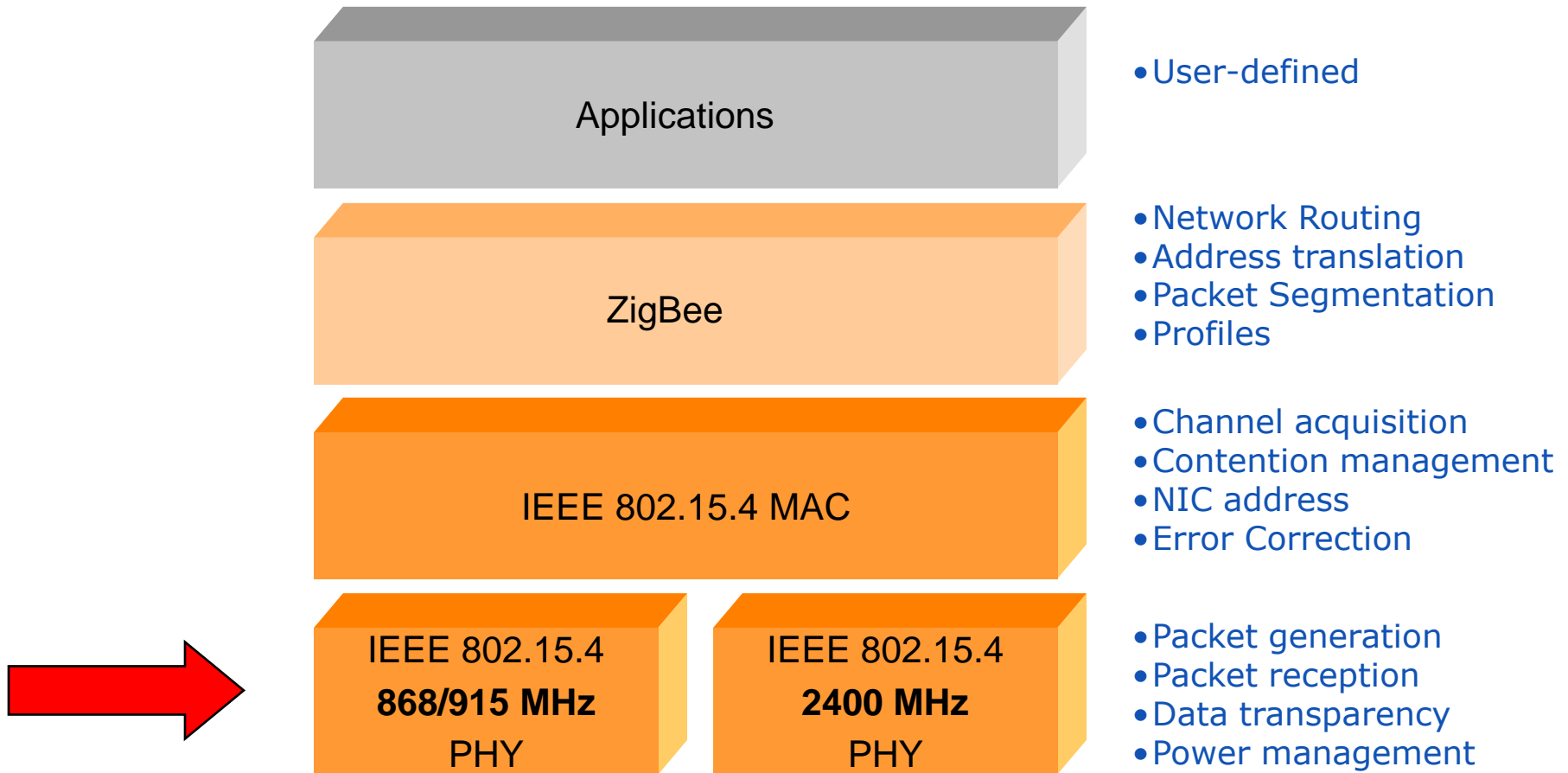
Dedicated to short range operation.

Easy to implement and with reliable data transfer.

Simple and flexible.

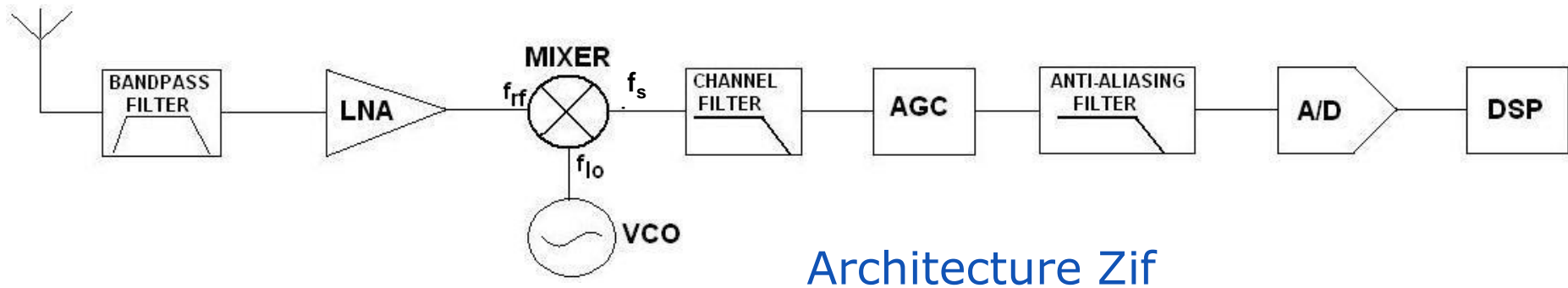
Band	Frequency Band	Bit rate	Symbol Rate	Modulation	Chip rate
868 MHz 1 channel	868-868.6 MHz	20 kb/s	20 Ksymbols/s	BPSK	300 Kchips/s
915 MHz 10 channels	902-928 MHz	40 kb/s	40 Ksymbols/s	BPSK	600 Kchips/s
2.4 GHz 16 channels	2.4-2.4835 GHz	250 kb/s	62.5 Ksymbols/s	OQPSK	2 Mchips/s

# Zigbee Architecture

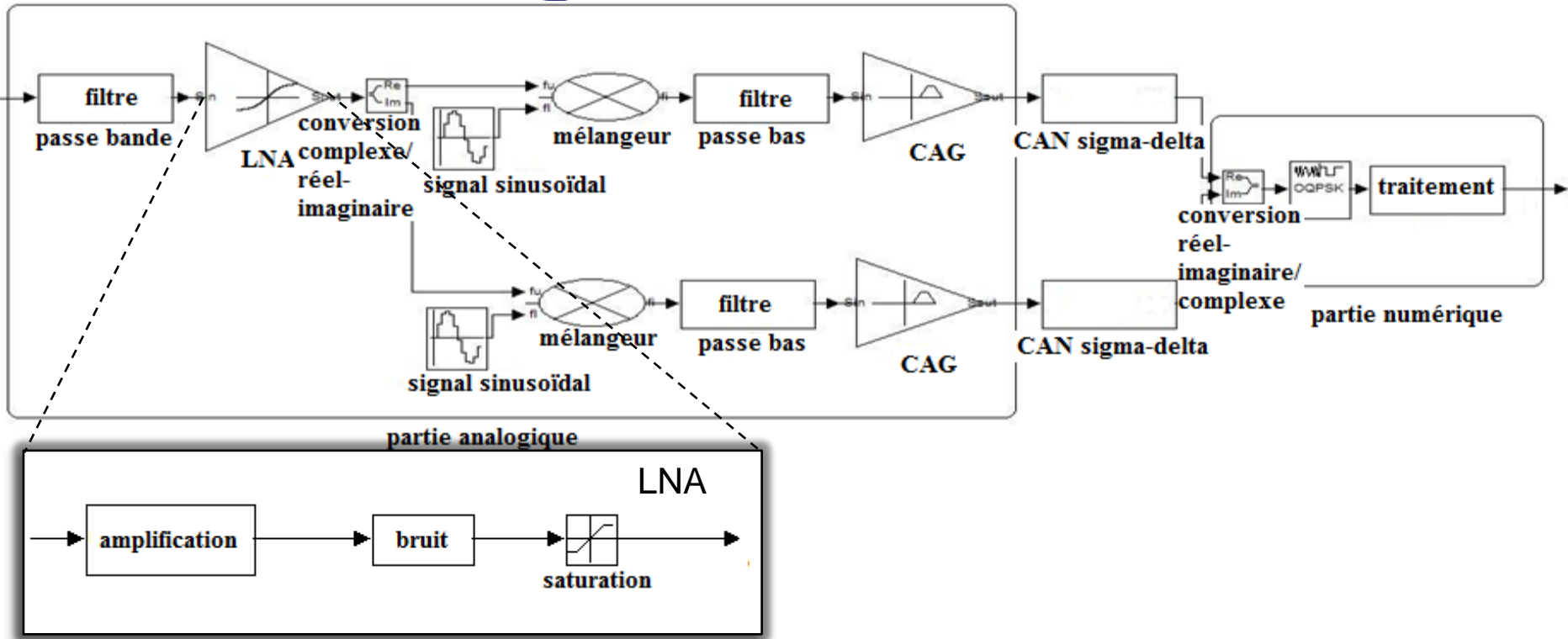


# Example 1 : architectural exploration

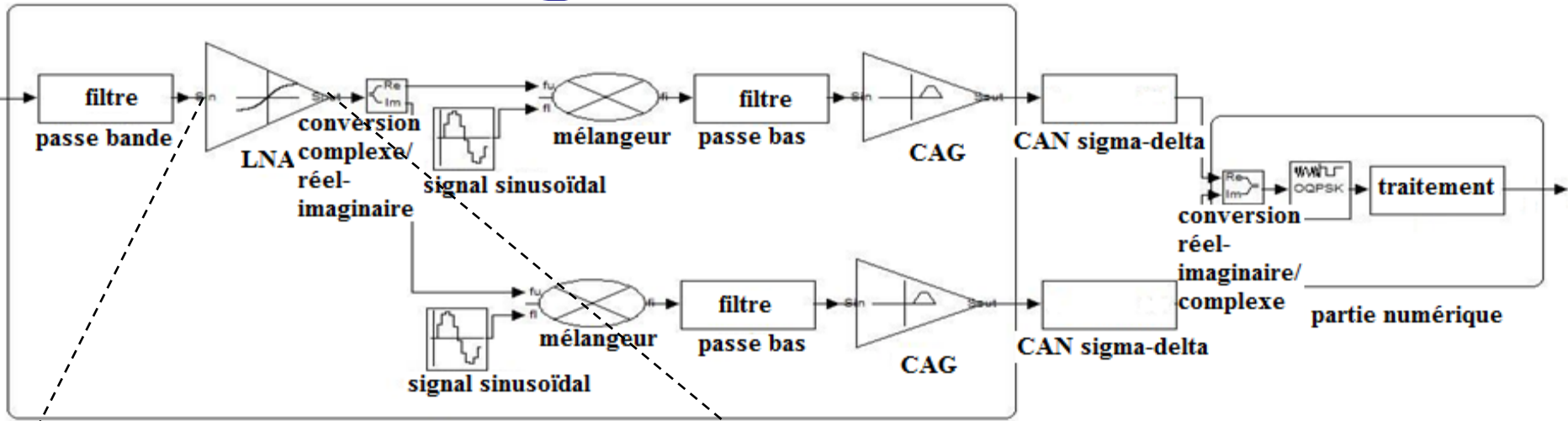
Is to choose the blocks that will form the chain of communication and their locations



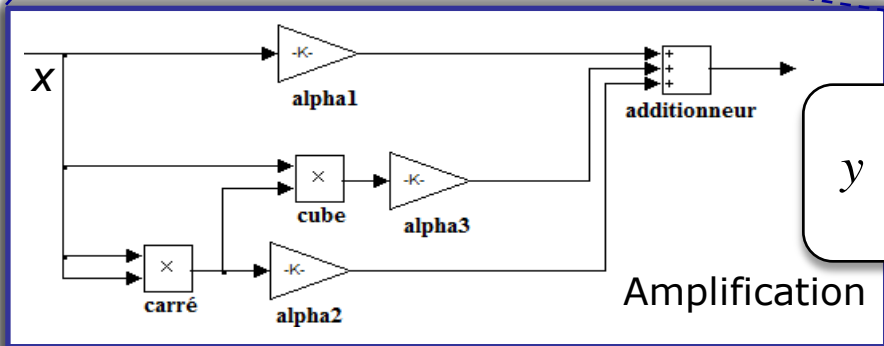
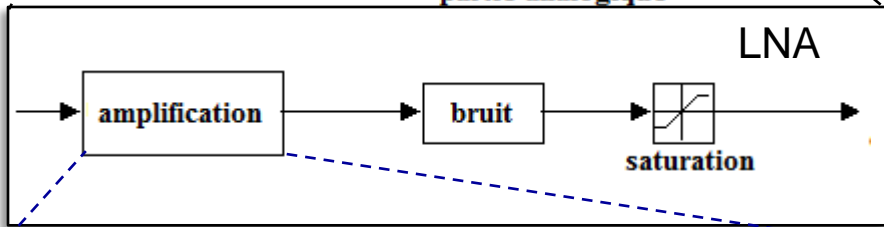
# Modeling of an RF receiver



# Modeling of an RF receiver

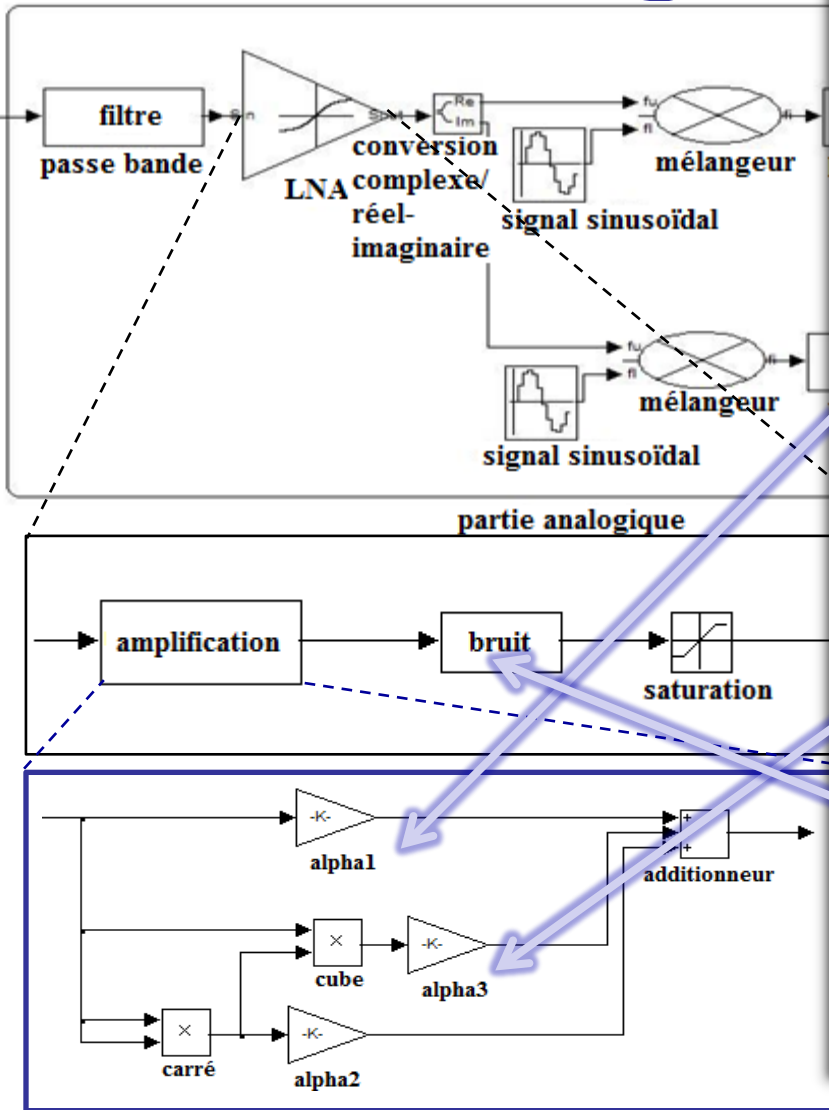


partie analogique



$$y(t) = \alpha_1 x(t) + \alpha_2 x^2(t) + \alpha_3 x^3(t)$$

# Modeling of an RF receiver

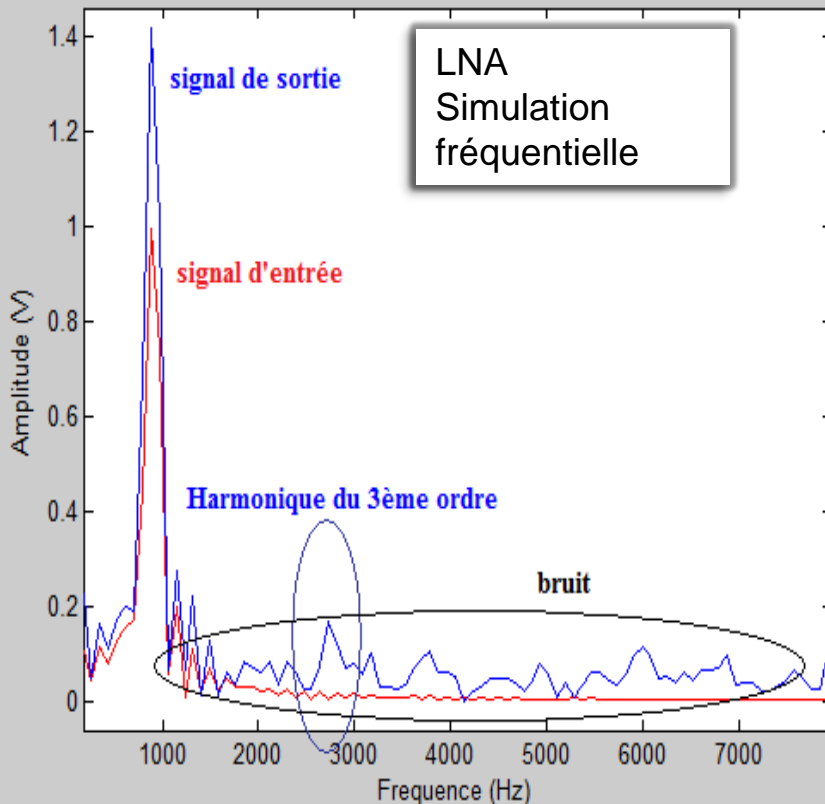


The screenshot shows the **Function Block Parameters: LNA** dialog box. The title bar indicates it is for an **amplificateur à faible bruit (mask)**. The parameters are as follows:

- Gain de l'ampli (dB):** 0
- Amplitude du point de compression de 2nd ordre (dBm):** -inf
- Valeur:** -inf
- Amplitude du point de compression de 3e ordre (dBm):** User-defined
- Valeur:** 10
- Noise Figure NF (dB):** User-defined
- Valeur:** 3
- Point de compression IIP1 (dBm):** -inf

Buttons at the bottom include **OK**, **Cancel**, **Help**, and **Apply**.

# Test of a component

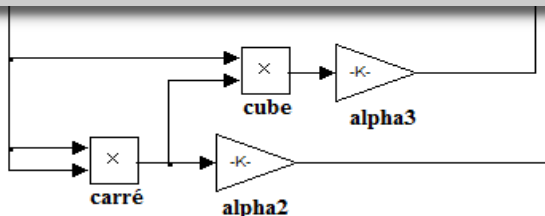
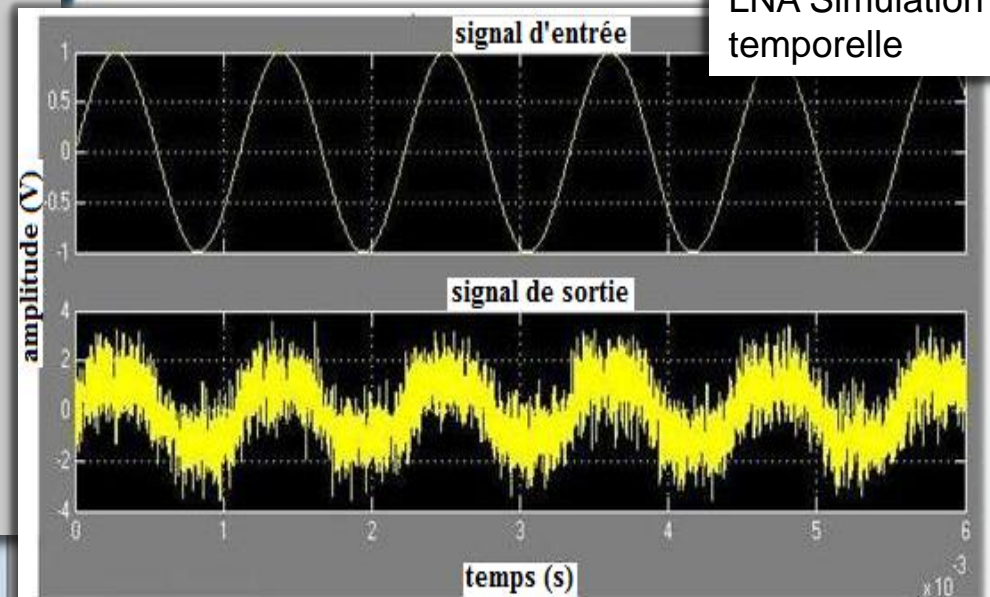


Function Block Parameters: LNA

amplificateur à faible bruit (mask)

Parameters:

Gain de l'ampli (dB)



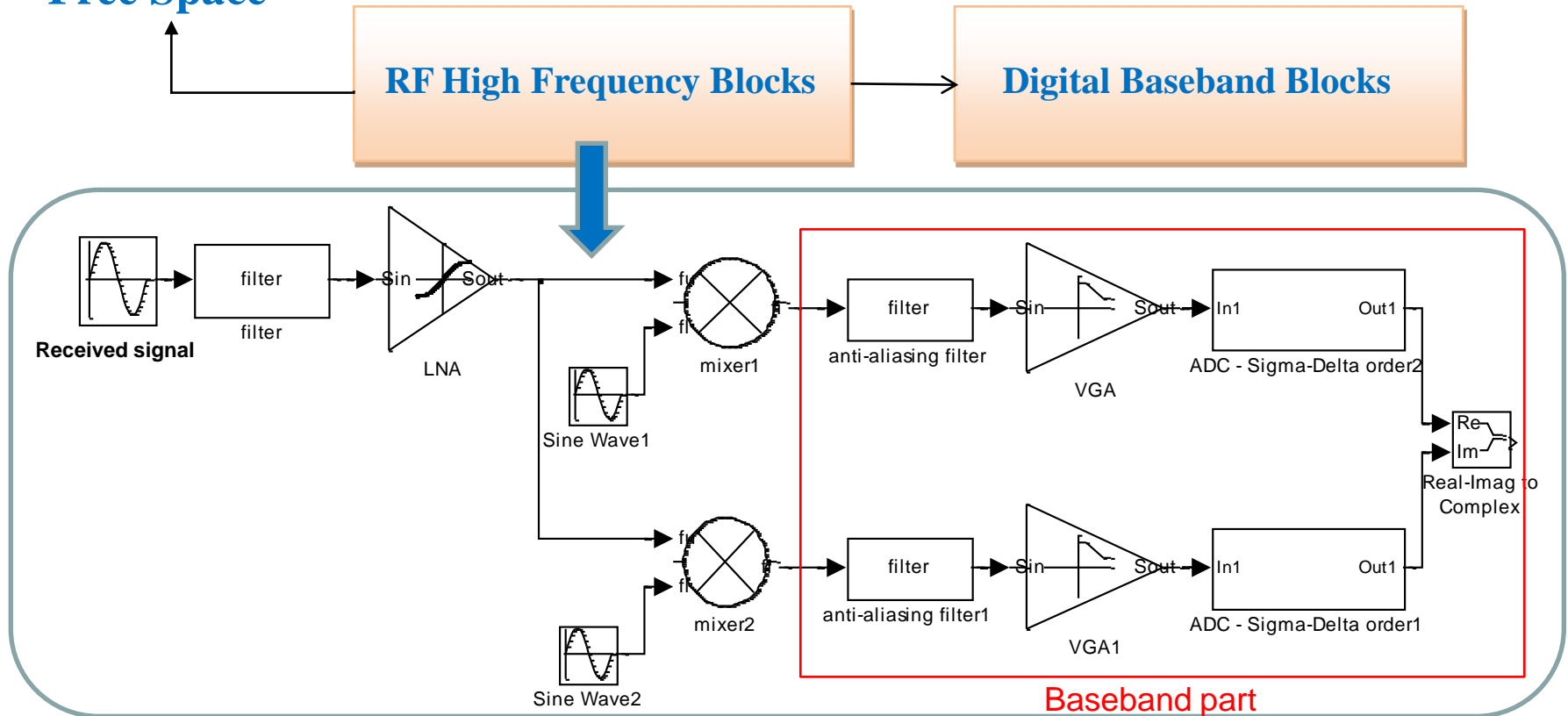


# Test of a receiver

Free Space

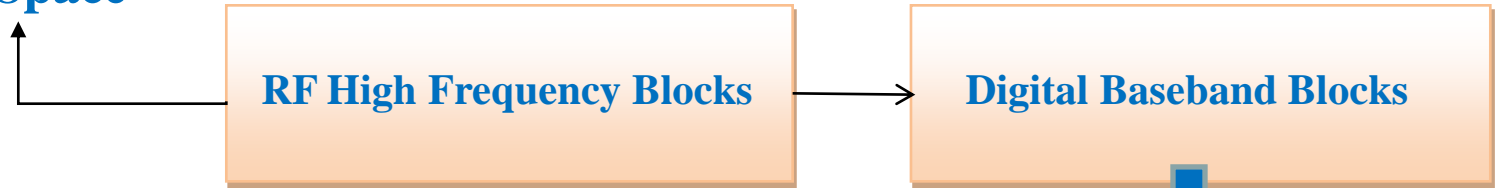
RF High Frequency Blocks

Digital Baseband Blocks

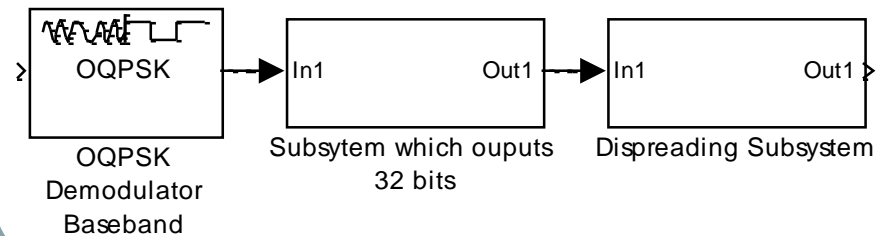


# Test of a receiver

Free Space



## For the OQPSK demodulation



# Test of a receiver

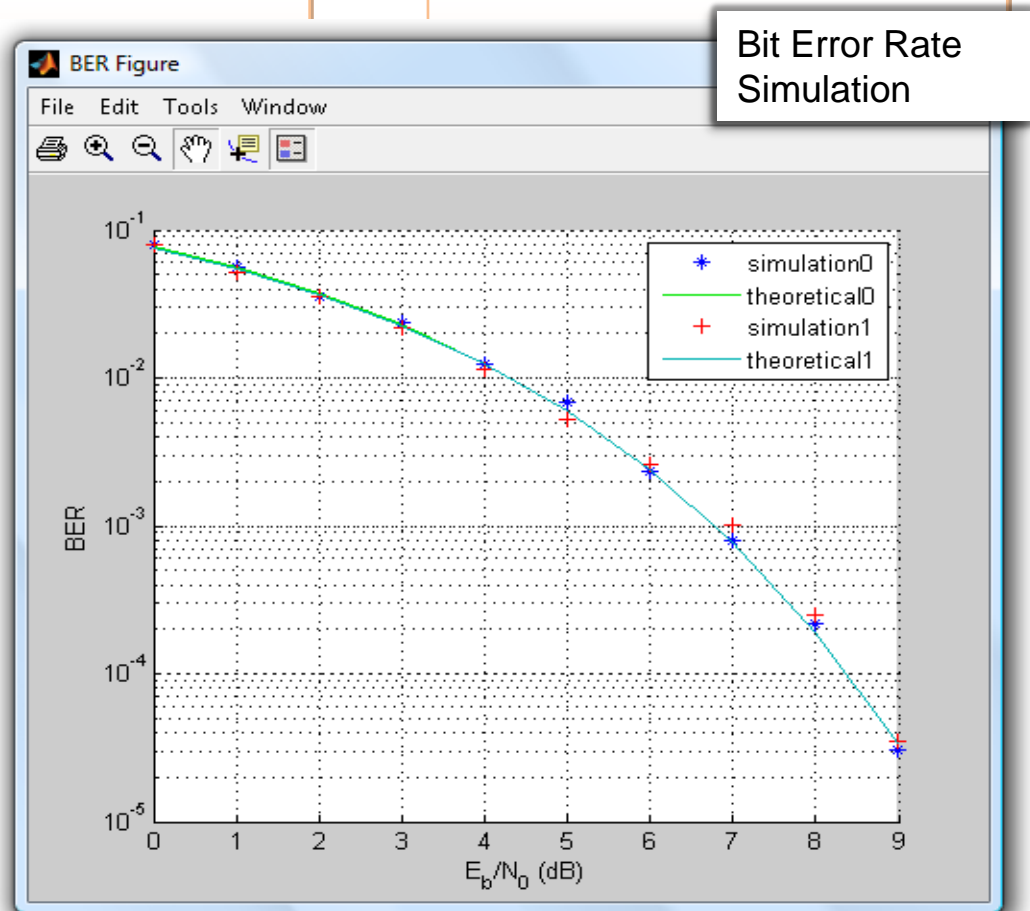
Free Space

RF High Freq

-“Simulation 0” refers to the **BPSK** chain

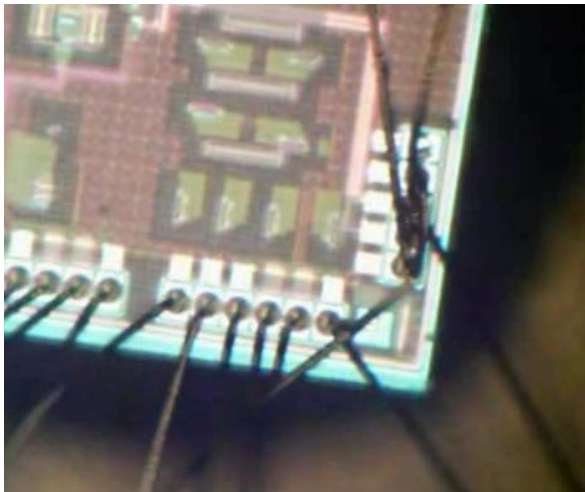
-“Simulation 1” refers to the **OQPSK** chain

- “Theoretical 0 and 1” refer to the **theoretical curves of the BPSK and OQPSK**



## Exemple 2 : calcul de la spécification

Consist in determining the parameters or the constraints of each block, so that the complete chain meets a standard.



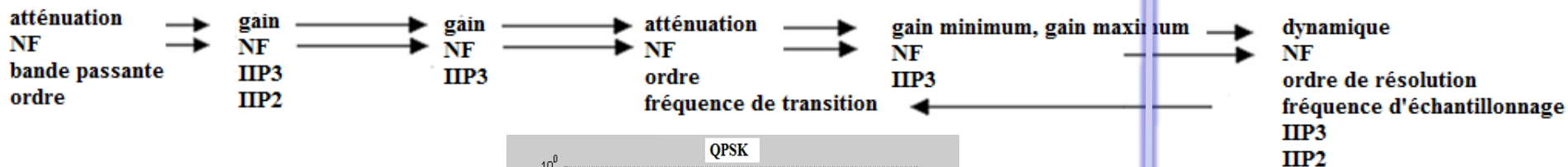
For example, for a Analog to Digital Converter (ADC), it is necessary to determine the noise level and the dynamics of the signal at its entry.

# Calculation of the specification

## Model of Receiver

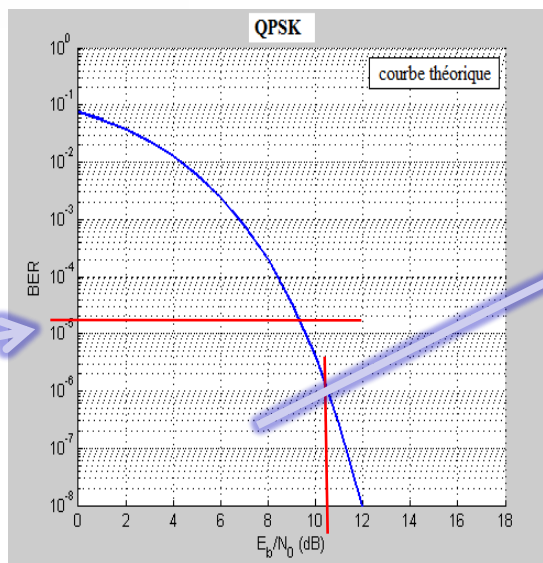


## Parameters



$$PER = 1 - (1 - BER)^N$$

$$N = 32 \Rightarrow BER = 0,3\%$$



$$NF = SNR_{in} - SNR_{out}$$

$$SNR_{out} = \frac{E_b}{N_0} - 10 \log \left( \frac{B}{D} \right)$$

Bande passante d'un canal B	2 MHz
Débit binaire D	250 kbit/s

# Calculation of the specification

Matlab  
Graphic  
User  
Interface

The screenshot shows the 'générateur' software interface with several key sections:

- Estimation détaillée**: A central panel with sub-sections for 'spécifications d'un récepteur', 'composants architecture homodyne', 'composants architecture low IF', and 'composants architecture superheterodyne'. Each section contains radio buttons for selecting components like 'Filtre RF', 'LNA', 'mélangeur I,Q', 'Filtre passe bas antireplément', and 'AGC'.
- format des résultats**: A panel on the left with 'Résultats' (SNR, IIP3, SFDR) and 'Paramètres du standard' (Sensibilité, Bande Passante, SNRminimum).
- Choix des composants**: A callout box pointing to the component selection options in the 'Estimation détaillée' section.
- Spécification système**: A panel at the bottom left with fields for 'Amplitude du point de compression du 3e ordre(IIP3)', 'Noise Figure(NF)', and another 'Amplitude du point de compression du 3e ordre(IIP3)'. Below it is a flow diagram: 'SNR to BER conversion' box pointing to a 'Display' box.
- Estimation simplifiée**: A dialog box titled 'Source-Block Parameters: conversion' with input fields for 'SNR', 'bande passante (Hz)', and 'débit binaire (bits/s)', and 'OK', 'Cancel', and 'Help' buttons.

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# Summary, Future work

- ❑ Development of a toolbox allowing the validation of a transmission chain, architectural exploration and verification of a specification.
- ❑ Application: simulation of RF terminals in accordance with the standard IEEE.802.15.4



# Summary, Future work

- ❑ Making the link between behavioral parameters and physical parameters in order to automate the impact of each other.
- ❑ Integrate the physical layer in a Platform for Wireless Protocols Design Explorations.

# Questions?

Thanks for your attention !





# Dimensionnement d'un récepteur homodyne RF

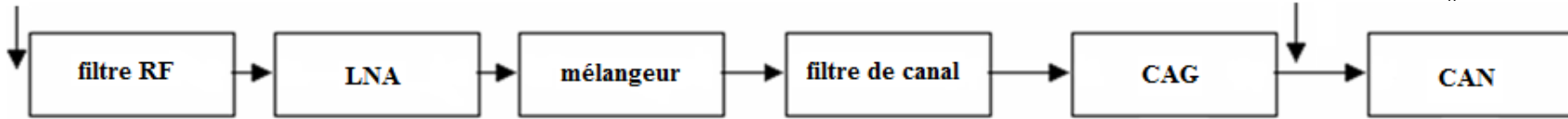
$$SNR_{in} = S - N_t$$

$$N_t = 10 \log(kBT)$$

$$F = 1 + F_{RF} - 1 + \frac{F_{LNA} - 1}{G_{RF}} + \frac{F_{mix} - 1}{G_{LNA} \cdot G_{RF}} + \frac{F_{AA} - 1}{G_{mix} \cdot G_{LNA} \cdot G_{RF}}$$

$$NF = SNR_{in} - SNR_{out}$$

$$SNR_{out} = \frac{E_b}{N_0} - 10 \log\left(\frac{B}{D}\right)$$



atténuation  
NF  
bande passante  
ordre

gain  
NF  
IIP3  
IIP2

gain  
NF  
IIP3

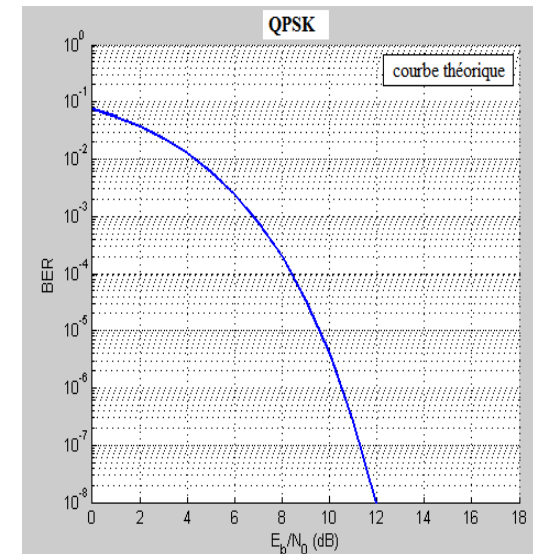
atténuation  
NF  
ordre  
fréquence de transition

gain minimum, gain maximum  
NF  
IIP3

dynamique  
NF  
ordre de résolution  
fréquence d'échantillonnage  
IIP3  
IIP2

Bande passante d'un canal B	2 MHz
Débit binaire D	250 kbit/s
Sensibilité du récepteur S	- 85 dBm
Valeur maximale du signal $S_{max}$	- 20 dBm
PER	1%

$$PER = 1 - (1 - BER)^N \implies N = 32 \implies BER = 0,3\%$$



# Calcul des spécifications

bruit

gain

non-linéarités

Équations

Calculs

Optimisation

Spécification

$$F = 1 + \frac{F_1 - 1}{G_1} + \frac{F_2 - 1}{G_1 G_2} + \frac{F_3 - 1}{G_1 G_2 G_3} + \dots$$

$$NF = 10 \log F \quad SNR_{in} = S - N_t \quad SNR_{out} = SNR_{in} - NF$$

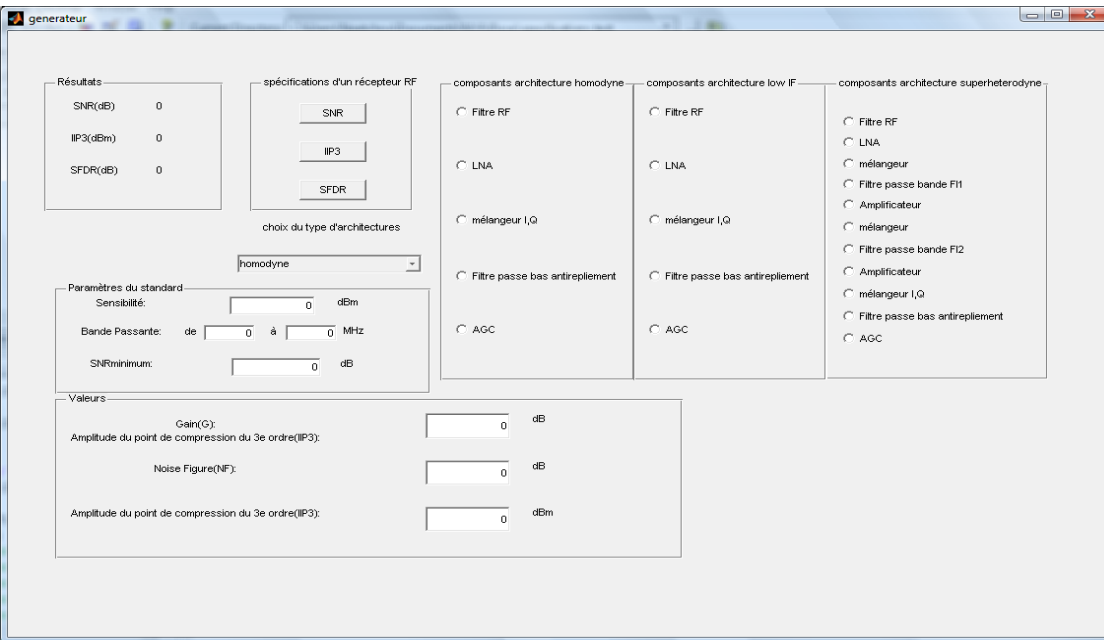
$$\frac{1}{A_{IP3}^2} \approx \frac{1}{A_{IP3,1}^2} + \frac{G_1^2}{A_{IP3,2}^2} + \frac{G_1^2 G_2^2}{A_{IP3,3}^2} + \dots$$

$$SFDR = \frac{2}{3} IIP3 - S_{min} \quad S_{min} = N_t + NF$$

**La plus grande dynamique du signal à la sortie de la partie analogique**

$$\frac{E_b}{N_0} = SNR_{out} + 10 \log \left( \frac{B}{D} \right)$$

# Calcul des spécifications



$$F = 1 + F_1 - 1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 \cdot G_2} + \frac{F_4 - 1}{G_1 \cdot G_2 \cdot G_3} + \dots$$

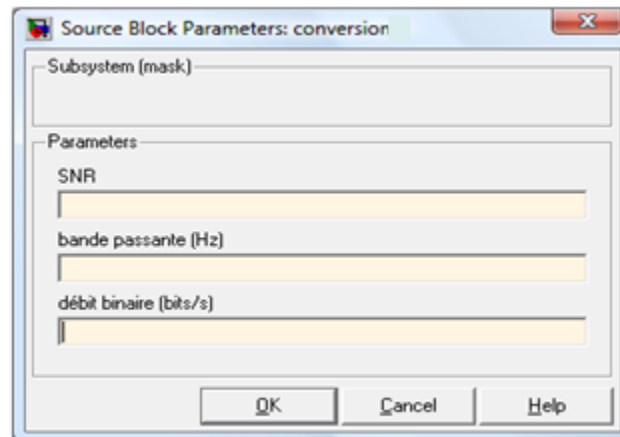
$$NF = 10 \log F \quad SNR_{in} = S - N_i \quad SNR_{out} = SNR_{in} - NF$$

$$\frac{1}{A_{IP3}^2} \approx \frac{1}{A_{IP3,1}^2} + \frac{G_1^2}{A_{IP3,2}^2} + \frac{G_1^2 \cdot G_2^2}{A_{IP3,3}^2} + \dots$$

$$SFDR = \frac{2}{3} IIP3 - S_{min} \quad S_{min} = N_i + NF$$



**La plus grande dynamique qui ne génère pas de bruit supérieur au plancher de bruit**



$$\frac{E_b}{N_0} = SNR_{out} + 10 \log \left( \frac{B}{D} \right)$$