

Optimal specification of a receiver blocks from global specifications

Example of IEEE 802.15.4

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Introduction

poster presents a novel method for calculating This optimal specifications of the blocks of a RF receiver from the constraints of a standard and architecture. An application of the method is made for the standard IEEE 802.15.4. The novelty of this method is to offer optimal and realistic solutions, thanks to a nonlinear constrained optimization.

RF standard Calculation of constraints of the receiver

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Generalized Reduced Gradient (GRG) with the solver of MS Excel

Sequential Quadratic Programming (SQP) with the optimization tool of Matlab





RF Filter	LNA	Mixer	Channel Filter	AGC	AA Filter	ADC
Gain	Gain	Coin	Gain	NF	Coin	Dynamic
NF	NF	- Gain NE	NF	IIP3	- Galli NE	Order
Rec. Band	IIP3		Band width	Gain _{Max}		Resolution
Order	IIP2	IIP3	Order	Gain _{min}	1 _{sampling}	IIP3,

Tools and methods

Parameters	IEEE 802.15.4 for PHY 2450 MHz	5
Frequency Band	2400-2483.5 MHz	
Channel Bandwidth	2 MHz	<u>8</u>
Channel spacing	5 MHz	
Coverage	Worldwide]
Spread Spectrum Technique	DSSS	SI SI
Modulation	O-QPSQ with MSK]
Bit Rate	250 kbit/s	
Symbol Rate	62.5 ksymbol/s	
Number of channels	16	
Receiver Sensitivity	-85 dBm]

Calculation of the global specifications of the receiver

$N_0 = 7.78 \text{ dB}$ NR_{out} = -1.14 dB SNR_{in} = **25.82 dB** *NF* = **26.96 dB** *DR_{in}*= **65 dBm** $DR_r = 63.6 \, dB$

Examples of result



[dB]	Typical	G _{max}	G _{max}	G _{min}	G _{min}
	values	NF _{min}	NF _{max}	NF _{min}	NF _{max}
$NF_{LNA} \in [1, 4.4]$	2.22	4.39	1	1	4.39
NF _{MIX} ε [10, 13]	10.00	10	10.000	10.0007	10
$NF_{FC} = 1.5$	1.49	1.49	1.501	1.5001	1.49
NF _{CAG} ε [5, 35]	16.99	4.99	5.048	12.248	4.99
NF _{FAA} =1.5	1.16	1.49	1.501	1.5	1.49
$G_{LNA} \in [5, 20]$	14.99	20	19.99	19.99	20
G _{MIX} ε [0, 17.5]	0	17.49	17.44	16.60	0
$G_{FC} = 0$	0	0	0	0	0

 $33 \text{ dB} < [G_{LNA} + G_{MIX} + G_{FC} + G_{CAG} + G_{FAA}]_{Opt.} < 100.24 \text{ dB}$



The problem can be summarized in the minimization of a cost function (F(=nf)) or *IIP3*), under two types of constraints:

- the sum of the gains of all blocks in the chain must be between Gain_{Max} and Gain_{min}
- the possible values of solutions are either fixed or within a certain range (see Table: Realistic values)

Realistic values

Blocs	Gain (dB)	NF (dB)	IIP3 (dBm)
Filtre RF	0	1.5	13.42
LNA	5 à 20	1 à 4.4	-22 à 15.8
Mixer	0 à 17.5	10 à 13	-12 à 24
Filtre de canal	0	1.5	13.42
CAG	5 à 40	5 à 35	4.38 à 20
FAA	0	1.5	13.42

$G_{CAG} \in [5, 40]$	20	40	38.406	14.6905	4.99
Min NF _{Total}	1.30	1.30	1.30	1.30	1.30

Conclusion

We have proposed an optimization method that suggests an optimal distribution of the parameters of specification on the various blocks of the system, according to the constraints of each block, and minimizes system constraints such as noise figure and total distortion of 3rd order.

Once we put minimization problem in its general form, we applied two algorithms for optimization: the GRG and SQP.

Another way to do it would use the multi-objective optimization that would give optimum gain values for both cost functions together, not separately.

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